# MARKETS FOR WATER QUANTITY AND QUALITY: ADDRESSING WATER SCARCITY AND POLLUTION IN SOUTHERN ALBERTA

A Thesis Submitted to the College of

Graduate Studies and Research

In Partial Fulfillment of the Requirements

For the Degree of Master of Arts

In the School of Environment and Sustainability

University of Saskatchewan

Saskatoon

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# ABSTRACT

Where water resources are scarce and water quality is diminishing, market–based instruments have better potential than government regulation alone to increase the efficiency of resource use, to reallocate water to other uses and to improve water quality in an efficient and equitable manner.

The SSRB is a region in Southern Alberta known for water scarcity, growing competition for water and, an increasing threat of pollution by point and non-point sources. This research has addressed the perceptions of stakeholders about proposed system of water quality trading to supplement the existing system of government regulation and water trading. A survey was structured to examine stakeholders' perceptions about (1) resource status; (2) their rights and responsibilities under current system of administration, and (3) their rights and responsibilities under the proposed system.

Survey results revealed stakeholders concerns about the ability of both existing and proposed systems to secure their access to water if annual water supply continues to decrease. Despite concerns about increasing scarcity respondents did not perceive transferability of water licences as important due to lack of trading experience and existence of regulatory barriers that impede markets and discourage participation. Reluctance to explore markets could have been as well related to the high risk of losing the unused water.

Under the proposed system stakeholders' perceptions of their abilities to secure rights pertaining to water quality improved. However, obtained data were insufficient to judge with certainty the applicability of the proposed system in the region. Results were inconclusive to determine the extent and origin of non-point source pollution by agriculture. Also, research is needed to determine how elimination of potential institutional barriers, i.e. a risk to lose water and inability to maintain private licences to instream flow, would influence stakeholders' perceptions about their rights and responsibilities under proposed system.

## ACKNOWLEDGEMENTS

First of all, I would like to record my gratitude to my supervisors, Dr. Marie-Ann Bowden and Dr. Hayley Hesseln, for their continuous guidance and support throughout the work. Meanwhile, I gratefully acknowledge my advisory committee Dr. Kenneth Belcher and Dr. Robert Patrick as well as the external examiner Dr. Joel Bruneau for their direction and advice along this research.

I also want to extend my special gratitude to my department's staff, faculty members and fellow students for their help during my study and in everyday life. Special thanks to my family for their unconditional love and confidence.

I wish to thank all people who helped me with my studies and research. Special thanks to David Hill at University of Lethbridge and Brent Paterson at Alberta Agriculture and Rural Development for their assistance with recruiting participants for field research.

Finally, I appreciate the financial support from the School of Environment and Sustainability and the College of Graduate Studies and Research.

# CONTENTS

# FIGURES

# 1 INTRODUCTION

## 1.1 Problem statement

Water is the basis of human well being. Many places in the world are now approaching the point of "peak water" or, in other words, they are experiencing severe shortages of the supply of clean water (Palaniappan and Gleick 2009). It is predicted that the needs of developed countries for water will increase by 18% by 2025 (UNEP, 2007); an increased demand that comes at a time when the global supply of freshwater is steadily decreasing and today's supply in some places is as low as half of the 1980's supply. A water crisis becomes inevitable where rising rates of consumption coincide with steadily declining supply (Anderson and Snyder 1997).

At the same time, pollution of surface waters has been increasing as a result of urban growth, unregulated non-point source runoff, and decreased assimilative capacity of water from diminishing natural water flows (Gillian and Brown 1997, Nicol and Klein 2006, Maas and Tefter 2008). Every year more than 500 million tons of pollutants are dumped into water bodies globally, of which 70% are untreated (World Bank 2007, UNEP 2010).

Although many factors influence water quantity and quality, two main conditions play a significant role in explaining the interdependent nature of these two dimensions. Provision of water quality is an important ecological service, which depends on the amount of flow available for assimilation and filtration of pollutants (Andersen and Snyder 1997, Vander Ploeg 2010, Palaniappan and Gleick 2009). Second, the amount of pollution dispersed into a water body is often proportional to the quantities of water withdrawn by various users and returned to the stream (Weinberg et al. 1993, Andersen and Snyder 1997, Eheart and Ng 2004). As a result, diminishing freshwater resources and increasing pollution have been related to the wasteful use of water, which arises with the lack of appropriate water quantity and quality management mechanisms (Anderson and Snyder 1997, Porto and Lobato 2004). Addressing the issue of water resources management is important to satisfy growing demand for clean water from competing uses, including environmental and ecological uses. Recognizing the benefits of conjunctive water quantity and quality management (i.e. management of the interdependence of water quantity and quality), regulators can allocate rights to use water and pollute thus accounting for both water use trends in the watershed and the ability of a stream to assimilate wastes resulting from such uses (Porto and Lobato 2004, Andersen and Snyder 1997, Woodward and Keiser 2002, Howe *et al.* 1986).

Extensive research has been done to examine the effect that water resource management such as administrative/command and control[1] or incentive-based approaches might have on achieving desirable economic, social and environmental outcomes. The literature has documented that incentive-based instruments drive water users' behaviours and can lead to more efficient allocation of scarce water resources than can traditional administrative systems (Stroup and Baden 1979, Howe *et al.* 1986, Brubaker 1995, Thobani 1997, Easter *et al.* 1999, Rosegrant and Gazmuri, 2001, Horbulyk 2007). Similarly, where environmental water quality is a concern, markets for water quality achieved remarkable results in meeting desired environmental objectives at a lower cost (Tietenberg 1990, Kraemer *et al.* 2004). Although other incentives based instruments, e.g. taxes or charges, are sometimes used to induce pollution reduction efforts by polluters, they were found inefficient in mitigating the cumulative effects where reduction is required from multiple sources with significant difference in control costs (Howe 1994). The advantages of market-based approaches include the flexibility in adapting to rapidly changing conditions as decisions are driven by price signals (Stroup and Baden 1979) that reflect water availability (Horbulyk 2007) and/or quality (Tietenberg 1990).

Typically, governments manage natural resources that are regarded as public property, and government oversight dominates over the decisions of individual users. Although it is generally believed that markets are mechanisms that function properly only if property rights are privately held, studies show that water markets can be implemented under different property

[1] Allocation of water resources by government regulation is an administrative approach; water pollution and quality control by government regulation is considered a command-and-control approach

rights regimes (McCay 1996). It is argued that users benefit from a resource commensurate with the degree to which decision-making powers are shifted to the users of the resource (Brubaker 1995). Although water is often a public-type good managed by government agencies, water transfers are, therefore, subject to approval by a government agency. Rights ultimately allow users to transfer water creating private incentives to use water efficiently, to sell saved water, or to avoid costs of purchasing additional water. This allocation method is distinct from traditional government regulation because part of the decision-making power has shifted away from government administrators to water users and users are capable of making decisions on water use based on its value in alternative uses.

Another market mechanism to manage water resources, known as water quality trading, has been used in some areas in the United States where deteriorating water quality had necessitated actions aimed at efficient pollution reduction from multiple sources, including non-point pollution sources, with different control costs (Woodward and Keiser 2002, Porto and Lobato 2004). Increased pressure on environmental water quality has led to tightening wastewater regulations and establishment of pollution caps (Fassbender 1994). The introduction of water quality markets, wherein lower-cost pollution credits could be obtained from reductions by non-point sources, has reduced the costs of achieving desirable environmental water quality (Tietenberg 1990, Porto and Lobato 2004, Selman *et al*. 2009). At the same time quality trading provided polluters with a flexible tool to meet pollution reduction requirements, thus shifting part of the decision making away from government to users.

In Canada, the ownership of water is vested with the Crown, which is also responsible for managing public water resources on behalf of citizens (Hurlbert 2007, Horbulyk 2007). Although water governance systems vary by province, in the West most authority to manage water resources was delegated from the federal government to the provinces (British Columbia, Alberta, Saskatchewan and Manitoba) by the 1930 Natural Resource Transfer Agreement (Percy 1977). Therefore, in Alberta the government has been responsible for issuing and revising water licenses since 1930. Licences have been issued and maintained in accordance with the system of prior allocation and other applicable laws (Hurlbert 2007, Percy 1977). Licences can be issued to individuals or groups, allowing them to manage water either individually or collectively. These licences do not create private property rights in water but rather a private right to use a property owned by the Crown. The extent to which this private interest is protected is subject to the conditions of the licence and applicable legislation (Hurlbert 2007, Saxer 2010).

In the South Saskatchewan River Basin (SSRB), Southern Alberta, the historical system of prior allocation[2] benefited some consumptive licence holders, e.g. agricultural, with quantities of water that were allocated based on the priorities of use and water availability at the time of allocation. By the time development extended beyond irrigation, the watershed became fully allocated and, therefore, unavailable for allocation for emerging uses, including environmental (Percy and Weber 2010). In the late 1990s, the Alberta government initiated allocation by market regulation by revising the Alberta Water Act (Cantin *et al.* 2005, Nicol and Klein 2006). Among the primary reasons for administering the market system was to reallocate water from existing uses (such as agriculture) into emerging uses (such as municipal and environmental) without increasing supply (Vander Ploeg 2010, Owens 2012).

Water quantity trading has been implemented in southern Alberta to also improve the efficiency of allocating water between competing uses. However, an increase in water productivity from decreased water consumption by some users does not necessarily lead to the

[2] In the Western U.S. and Canada historical water rights doctrines that constitute the legal basis for water governance are riparian and prior appropriation/prior allocation (Vander Ploeg 2010). Under the riparian doctrine, landowners whose property adjoins a flowing water body have rights to make reasonable use of the water, i.e. use water for domestic or production purpose as long as this use does not substantially diminish or otherwise significantly impair the rights of other users (Andersen and Snyder 1997). Expansion of human settlements beyond land adjoining to water bodies called for a more novel method for water allocation. The prior appropriation doctrine, commonly known as First-in-Time-First-in-Right (FITFIR), facilitated this expansion and economic growth by granting water rights to those who first claimed the beneficial use of the water. Property rights of those who claimed the beneficial use are protected by the appropriative doctrine in time of shortage on a FITFIR i.e. senior rights holders have priority over junior rights holders in satisfying their entire appropriated volume of water (Andersen and Snyder 1997).

achievement of social and environmental objectives (Cantin *et al.* 2005, Berkes 1996). For example, this might include protecting other users from damage or leaving more water instream to improve services maintained by instream flow. In fact, activating previously unused licences in Southern Alberta might lead to higher rates of consumptive use, increased drainage of pollutants and compromised ability of the stream to dilute pollution (Bjornlund 2010, Berkes 1996).

Water quality in Alberta has been traditionally regulated using the command-and-control approach, whereby point-source polluters have been strictly regulated and over time required to undertake significant improvements to treatment technologies, thus reducing pollution (Matisz *et al.* 2010). However, the effect from this reduction has been compromised due to urban growth and intensive agricultural development (Matisz *et al.* 2010). Agricultural activities constitute the greatest increase in water use in Southern Alberta (Vander Ploeg 2010, Percy and Weber 2010, Bjornlund *et al.* 2007). Pollution from nonpoint sources, agricultural in particular, is mostly unregulated, and therefore, the contribution to surface water pollution from these sources can be significant (Matisz *et al.* 2010). These factors coupled with increased consumptive demand negatively influence river flows and water quality.

Growing concerns about diminishing water quality, urban growth and intensive agricultural development in the SSRB make this region a potential area that could benefit from implementing water quality markets to complement water quantity markets. Where water resources are scarce and environmental water quality diminishes, and impact from agricultural water use on other users is evident, establishment of a pollution cap might constitute a limit to pollution and might set additional limits to consumption. A pollution cap specifies the maximum allowable loading of identified prevailing non-point source pollutants and will be derived based on the assimilating capacity of the stream, i.e. the amount of water necessary to maintain required surface water quality standards. Surface water quality standards determine the resulting pollution cap, which is reflective of the demand for water quality in the area. Establishment of quality trading might also help to equalize pollution abatement costs among users with different costs, i.e. cost-efficiency conditions (Tietenberg 1990). The equity condition is satisfied to the degree to which prices for water licences and discharge permits capture the value of water scarcity and quality (Weber 2001). Considering the interdependences between water quantity and quality, the pollution cap might motivate water users to leave more water instream to improve assimilative capacity of the stream, thus facilitating maximizing net social benefits from water use. Improvement of instream flow by private water users is, however, subject to favorable institutional conditions, i.e. secure entitlements to instream flow are legitimized and privately held (Andersen and Snyder 1997). Other instream flow users such as fishers and recreation users for example, might benefit from steady maintenance of sufficient streamflows, including reduced effects from eutrophication and improved aesthetics.

The overall potential benefits from implementing parallel quantity and quality markets can include:

- Reallocation for compensation
- Improved water quality
- Increased supply of instream flow
- Pollution reduction from nonpoint sources

It is argued that individuals act in their own interest as they perceive and “they do so within the prevailing institutional arrangement” (Stroup and Baden 1979). It is also believed that an effective institution will be one that is efficient, perceived by users as equitable and creates the incentives to conserve (Howe *et al*. 1986). Although studies prove that neither public administration nor market-based instruments can succeed absolutely in providing such a system of resource allocation, combining two types of markets might enhance benefits and relieve the societal burden of dealing with water scarcity and quality.

## 1.2 Research purpose and objectives

Benefits arising from the introduction of water quality markets might be significant and equitable to the interests of individuals and society at large. However, shifting to a new allocation process might increase uncertainty about the outcome unless strong drivers exist to trigger an institutional change (Howe *et al.* 1986). Users might accept the proposed system of parallel quantity and quality trading only if the proposed system has the potential to deliver important services that are undersupplied under the current allocation system. In general, the factors that might trigger such a change would be the acknowledgement by users that the following conditions exist:

- Water scarcity is perceived to be sufficient to initiate institutional change
- Water quality conditions are perceived to be sufficiently low to initiate institutional change
- The current water administration system does not address water quantity and quality in an efficient and equitable way

The goal of the proposed study was to examine the conditions that would lead to the introduction of market-based instruments as a means to allocate water quantity and quality. It is important to identify and understand conditions and possible barriers that might factor into the willingness or reluctance by stakeholders to accept these instruments. The purpose of the present work is to determine the acceptability of the dual market scheme (quality and quantity trading) based on stakeholders' perceptions of resource status and attainability of resource users' rights and responsibilities under existing and proposed systems of water administration. To test stakeholders' willingness to adopt a dual water-market scheme I will use a case study approach focused on southern Alberta. My research objectives are to:

- identify stakeholders' perceptions of the current resource status (scarcity/quality)
- evaluate stakeholders' perceptions of the current water administration including their experience with water markets
- evaluate the willingness to adopt a proposed water quality market mechanism

Using a case study approach, I will be able to assess perceptions regarding environmental and administrative conditions and the willingness of stakeholders to adopt market-based approaches to water management. Such information is important because understanding and including stakeholders' values can determine the viability of a proposed policy and will facilitate its implementation and buy-in by the community of water users.

## 1.3 Organization of the thesis

The thesis begins with a review of primary and secondary literature, respective legislation, peer-reviewed articles, and guidelines and reports regarding water allocation and administration, quality control and trading. The examples of water allocation and water pollution markets within the global context have been examined in order to define the conceptual framework for the proposed research. The study includes a review of documented advantages and disadvantages peculiar to administrative and market-based resource allocation approaches, and summarizes the conditions in which running both types of markets in parallel might result in optimal resource allocation.

The next section presents the survey methodology used to assess stakeholders' perceptions. I developed an online survey to examine the perceptions about existing and proposed water allocation and quality control systems. The surveyed population was divided into three categories: agricultural, municipal, and others – provincial regulatory, NGOs, and legal academic. The study area is the SSRB in Alberta, the second largest watershed in southern Alberta that consists of four sub-basins – the South Saskatchewan, Oldman, Bow and Red Deer Rivers.

The results of the survey are discussed in the following section and evaluated in the context of literature review findings. Finally, I conclude with findings and recommendations that reveal the potential to implement a system of parallel water quantity and quality markets in Southern Alberta.

# 2 WATER ALLOCATION MARKETS AND POLLUTION MARKETS

About one third of the world's population lives in regions with high to moderate water stress (World Resource Institute 1998). In the last 40 years the global population has grown rapidly and has passed the seven billion mark; water demand has doubled and water withdrawn annually exceeds the water replenishment rate (Deloitte 2012). According to UNEP (2007) by 2025 more than 1.8 billion people, almost two thirds of the world's population will live in locations with profound water scarcity.

At the same time, pollution of surface waters has been increasing as a result of urban growth, unregulated non-point source runoff and depleting streamflows. Where waste was once effectively diluted due to sufficient natural flow, the growing population and diminishing supply of natural flow have resulted in an impaired ability of watercourses for self-cleansing (Hanna *et al*. 1996). A 2006 assessment of water bodies in the United States found 48% of rivers and streams, 60% of lakes, reservoirs and ponds, and 61% of estuaries unsuitable for their designated use (Selman *et al.* 2009).

Pollution originates from two sources: point (identifiable) and nonpoint (unidentifiable) (Maas and Telfer 2008). Point sources can be regulated and include sewage plants and industrial facilities that discharge effluents directly to the receiving watercourse (*ibid*.). Nonpoint sources, originating from agricultural and urban runoff are characterized by the diffuse character of the pollution and in some cases account for the larger share of overall pollution loads. Typically, such sources are difficult or impossible to regulate because their sources cannot be identified (Selman *et al.* 2009). The agricultural sector, for example, accounts for 70% use of globally available potable water (1% of the total amount of water on Earth) and is the main nonpoint source of water pollution (UNEP, 2010). The agricultural sector is the main source of pesticides and nitrates in drinking water (i.e. water that is withdrawn for drinking purpose either directly from well or by water utility), and one of the major sources of excess nutrients, (e.g. phosphorus and nitrogen), in watercourses (Ongley 1996). Excessive amounts of nutrients cause eutrophication such as severe algae blooms, which then decompose resulting in oxygen-depleted water often referred to as dead zones. Globally, at least 405 areas including coastal waters where nutrients are discharged either directly or transported by rivers, experience severe oxygen depletion (Selman *et al.* 2009). Where a watercourse is affected by eutrophication, its ability to provide suitable drinking water is also affected and water treatment costs are significantly increased (*ibid*.).

It is argued that the lack of freshwater access and pollution are related to a lack of appropriate water resource management approaches (Anderson and Snyder 1997). Lacking the incentives to conserve water, users engage in wasteful use (Anderson and Snyder 1997, Cantin *et al.* 2005). Nonpoint pollution sources remain largely unregulated and, therefore, do not face the liability for their share of surface water pollution. Considering the need to satisfy growing demand for clean water and the growing recognition of the inherent value of ecosystems, implementing adequate water resource management mechanisms is crucial to economic growth, social wellbeing and preservation of environmental integrity.

The next section focuses on the types of water management institutions and instruments and their effectiveness in achieving socially optimal outcomes. The effectiveness of different water policy regimes and instruments are explored in the context of improving water quality and mitigating water scarcity and their ability to address the issues of quantity and quality conjunctively.

## 2.1 Property rights and institutional structure

Institutional structure has an important influence on individual behavior but dealing with a complex reality makes it difficult to identify structures that induce socially optimal behaviours, i.e. motivate individuals to make private decisions compatible with social objectives (Furubotn and Richter 2005, Howe *et al.* 1986). Different economic theories suggest different methods of governance. A legal system of governance, wherein rules are made and enforced exclusively by government authorities, is central to neoclassical economics, whereas new institutional economics relies more on informal contract enforcement, wherein decisions are made by individuals in a decentralized manner, or a combination of both (Easter *et al.* 1999). According to Furubotn and Richter (2005) neoclassical theory heavily relies on the legal system based on the assumption that the enforcing agency possesses full and complete information and is able to predict and prevent possible negative outcomes. This approach, however, disregards challenges of centralized monitoring and enforcement, and the importance of understanding the multiple agents' expectations and behaviours in a given context.

The theory of general equilibrium assumes that governments are impartial and that actions of the government are guided by the "principle of inviolability of property rights" (Furubotn and Richter 2005). However, in real life laws often accommodate large business enterprise and disregard or underestimate the interests of other users (Brubaker 1995). Furthermore, the complex or fluid nature of some resources makes it difficult to define rights clearly and, therefore, interests often intersect (McCay 1996, Brewer *et al*. 2006). Even if laws aim at promoting equity, in the absence of complete information about intersecting interests of the individuals, law enforcement might inadvertently protect property rights of some individuals while confiscating the rights of the others (Furubotn and Richter 2005, Baden and Stroup 1978).

Furubotn and Richter (2005), and Brubaker (1995) argue that the fate of a natural resource can be foreseen based on the state of ownership, i.e. public or private. Brubaker (1995) and Andersen and Snyder (1997) have highlighted the role of private property rights inherent to common law doctrine in protecting resources from degradation. The authors pointed out that where strong property rights to use a resource are held privately, users have strong incentives to protect the resource from overexploitation and other users from damage, as they are held responsible for that damage. On the other hand, McCay (1996) argues that unattenuated private property rights are no guarantee that their owner will conserve a resource, and that wise intervention by government is required to uphold all private property claims and to prevent externalities[3] and indirect ecological effects. Howe *et al*. (1986) highlighted the importance of

[3] An externality exists when some outcomes (positive or negative) of a decision were not accounted for in the process of the decision making (Stroup and Baden 1979). In case of decisions related to water use, such externalities can include changes in water quantity and quality downstream as a result of changes in water allocation and pollution upstream (Andersen and Snyder 1997)

institutions that are capable of providing sufficient coordination to make decentralized decision-making consistent.

Clear specifications of property rights regimes and definition of rights are critical to efficient resource management (Stroup and Baden 1979). Coase (1960) set forth the conditions that require property rights that are (a) exclusive – all benefits and costs associated with the resource are captured by the owner of a resource; (b) enforceable – the owner can prevent others from using or otherwise altering the resource, and (c) transferable – the owner of the resource can sell it in return for fair compensation.

However, several factors contribute to the complexity of defining rights to water clearly, selecting the right property rights regime and appropriate definitions. First of all, freshwater resources are regarded as common pool resources, which are characterized by low excludability and high rivalry (Berkes 1996, McCay 1996). In addition, water is regarded as a valuable public resource in most jurisdictions and, is therefore considered public property (Saxer 2010, Horbulyk 2007). As a result, governments manage water resources on behalf of the public, and the decisions of individual users are subject to scrutinized government oversight. Private rights to use rather than own water resources emerge from recognition that private interests in water exist (Saxer 2010). Market-based approaches are sometimes used to create private incentives to complement government regulation. Bundles of rights, or the extent to which rights are recognized and protected as private interests, vary across jurisdictions. The extent of such protection by government intervention, and resulting market effectiveness and efficiency, is subject to the conditions of the underlying legal system and other relevant regulations.

Recognizing that a rule made and enforced exclusively by government authority, is inevitably incomplete and, therefore, inefficient, Furubotn and Richter (2005), and Ostrom (1992), suggest decentralizing decision making by empowering individuals' abilities to respond to various incentives that would drive socially optimal behaviour among private agents. With regard to natural resource use, those incentives could be produced either by the resource itself, i.e. resource status, or be provided by markets, with additional limits set by wise government regulation (McCay 1996).

## 2.2 Water allocation

There are many ways to allocate water, with myriad outcomes in terms of equity and efficiency. Systems range in their ability to set limits on individual behaviours while allowing individuals to exercise rights to make decisions about water use, conservation and sharing while staying within those limits. Faced by increasing scarcity and diminishing water quality, it will be important to determine a desirable form of water resource allocation that maximizes social objectives, including water conservation.

According to Howe *et al.* (1986) socially optimal systems of water resource allocation should be flexible, efficient, must be perceived by the public as equitable, and create incentives for conservation. In other words, water should move to its highest value use, users should account for the value of water, including its quality in alternative uses, and users must be held responsible for altering the resource condition and resulting damage to other users. It should also reflect public values that would not be otherwise accounted for by individual decision-makers, i.e. the values of instream flow and environmental water quality (ibid.).

Institutions that allocate resources evolve in response to the resource status (McCay 1996), which in case of a water resource is the supply of the resource to satisfy the demand in water quantity and quality. Where the resource is abundant, in the absence of competition, water is allocated to emerging uses as needed and with fewer restrictions. As water resources become scarce, there is a need for the institutions that would allocate the resource in a manner that would balance the competing interests (Andersen and Snyder 1997). Therefore, resource condition is an important factor in accessing the appropriateness of selected institutions. Also, behaviour of private agents and resulting decisions to a greater extent depend on the way their rights and responsibilities to use the resource are defined and enforced under different systems of governance (Rosegrant and Gazmuri 2001).

Instruments to manage water quantity and quality range from administrative or command-and-control to incentive-based. Administrative or command-and-control instruments are composed of regulations and standards established and enforced by government authorities to execute water resource allocation and quality control. In contrast, market-based approaches are incentive-based instruments where individuals make decisions about using the resource in response to price signals established by markets.

### 2.2.1 Water allocation through public administration

Under an administrative allocation system, a public authority is solely responsible for the assessment of current water demands and uses its coercive power to initially allocate, physically distribute, and if necessary, reallocate water to alternative uses (Rosengrant and Bingswanger 1994). Instream uses, such as fisheries, wildlife, recreation and navigation, are secured through reservation of minimal streamflow and restrictions imposed on other water users through diversion caps (Jillilan and Brown 1997, Dinar *et al.* 1997, Kwasniak 2006).

Several disadvantages have been associated with the public administration of water rights allocation, especially where watercourses have reached their allocation limits. Those disadvantages stem from government's discrete authority with respect to reallocating water when demand for a resource increases and new users claim water, and insufficient security of private water rights, which diminishes private incentives (Andersen and Snyder 1997).

Sectors with historical senior water rights, like the agricultural sector, that have a higher investment in water, resist giving up their water and are likely to protest compulsory reallocation. Even in the face of changing demands for water, any reallocation by a government authority would undergo a lengthy process of negotiating compensation with the losers (Thobani, 1997, Rosengrant and Bingswanger 1994). This happens because government authority has limited knowledge about the value of the damage or loss to individual users, and in making the decision to compensate might either overestimate or underestimate the value of the damage, thus leaving an individual or society worse off (Brubaker 1995). A farmer might value his foregone property higher than the compensation offered and society might end up bearing higher costs of compensation, as government authority has no incentive to make economically viable decisions other than those concerned with long-term political accountability (Stroup and Baden 1979). If reallocation instream is not voluntary, then governments can secure only minimal flow reservation, often insufficient to maintain essential ecosystem services (Andersen and Snyder 1997)

Facing a threat of losing unused water and lacking the incentives to save it, private rights holders engage in its wasteful use and are discouraged from investing in water-efficient technologies (Andersen and Snyder 1997). Facing pressure from new users and resistance from existing users to relinquish water, governments are forced into satisfying demand by increasing supply, i.e. construction of massive waterworks that come at even greater costs to the environment and society (Andersen and Snyder 1997).

### 2.2.2 Water allocation by means of markets

As the issue of water scarcity grows in tandem with economic growth and urbanization, and watercourse allocations reach their limits, policy-makers have expanded their attention to explore incentive-based approaches – markets in particular – as a means of complementing government regulation. Unlike administrative systems of allocation, a market approach constitutes a voluntary mechanism to reallocate water through price signals that inform the decisions of buyers and sellers and channel water to its highest-value uses (Stroup and Baden 1979, Howe *et al.* 1986, Owens 2012, Horbulyk 2007).

The ability to sell water induces investments in water-saving technologies, thus encouraging technological innovation (Thobani 1997, Horbulyk 2007). Allowing the price of water to fluctuate according to supply and demand, water markets induce users to consider the full opportunity cost of water, including the cost in alternative uses (Howe *et al.* 1986, Rosegrant and Binswanger 1994). As a result, the user will have little incentive to engage in wasteful use as long as he has the opportunity to sell the saved water in return for fair compensation as determined by the market. Facing the necessity to pay for any additional water, users responsible for distribution of water would be motivated to maintain leak-proof distribution infrastructure and other measures that would encourage water-saving behaviour.

It is generally recognized that allocation of scarce water resources by market regulation is more efficient than by government administration alone because individual behaviours are driven by stronger incentives to conserve water – incentives resulting from adding a transferability element to the definition of property rights (Bjornlund 2006, Easter *et al.* 1999, Rosegrant and Gazmuri, 2001). Although users' decisions about water use are voluntary, water markets help to induce socially optimal behaviour, i.e. increased water use efficiency and voluntary reallocation of existing supply to other uses.

### 2.2.3 Government regulation of water markets

Despite the recognition that markets can help to reallocate water and facilitate efficient water use, there are a number of challenges associated with this allocation approach. According to (Brennan & Scoccimarro 1999, Howe 1998, *Easter et al.* 1999, Weinberg *et al.* 1993, Cantin *et al.* 2005, Brewer *et al.* 2006, Owens 2012) third-party effects and damage to the environment, including changes in water quality are externalities that might be induced by water transfers.

With regard to third-party effects, the argument is that other legitimate users are damaged as a result of water transfers (Howe *et al.* 1986). For instance, in irrigation only some water is actually consumed during the irrigation process –the unconsumed part, i.e. return flow, usually returns to the hydrological system and becomes available to other users downstream of the irrigated property. However, occasionally, there will be a decrease in drainage flow when users upstream sell saved water away from the original diversion point. This activity can inadvertently damage rights holders immediately downstream if they rely on this return flow for their water supply or dilution of wastes (Andersen and Snyder 1997). A possibility to transfer the saved water and so-called "sleeper rights" – volume of water that was envisaged by allocation but was not actually used – almost inevitably leads to increased consumptive use by the transferee (Bankes 2006) unless saved or previously unused water is reallocated instream. As a result less water is left for the aquatic ecosystems and wastewater dilution. Intensification of consumptive use might in some cases lead to increased pollution and as a result, a detrimental impact on water quality (Weinberg *et al.* 1993, Andersen and Snyder 1997).

Andersen and Snyder (1997), Saxer (2010), Bauer (2004), Howe (1998), McCay (1996), Bjornlund (2006) acknowledge that government intervention is necessary to prevent public and private users from potential damage resulting from externalities. However, Andersen and Snyder (1997), Easter et al (1999), Rosegrant and Binswanger (1994), Rosegrant and Gazmuri (2001), Thobani (1997), Bjornlund (2010) argue that excessive government intervention impedes allocation by markets. All of the above conditions and contradictory outcomes of unregulated and over-regulated water markets can be exemplified by two comparatively distinct systems of implementation: water markets in California, one of 12 arid western U.S. states where markets are strictly regulated and Chile, which implemented a free market in water rights.

In California, title to water belongs to the state and private rights to use water are established within the system of prior appropriation (Saxer 2010). State water authorities are responsible for determining and enforcing the rules for using water and protecting instream flow interests on behalf of the public. Markets are authorized under California Water Code, section 475 (1990), "in a manner that protects the interests of other entities who have rights to, or rely on, the water covered by a proposed transfer". The "no injury rule" addresses the issue of return flow and other third-party effects, the protection of which is exercised through restrictions on transferability of private rights (Mentor 2001, Rosegrant and Gazmuri 2001, Thobani 1997, Dunning 2003). Although no specific stream flows have been mandated, the state has the authority to acquire and hold water rights for enhancing flow whenever necessary. The State has the right to exercise any restrictions of existing water uses in order to secure instream flow interests. However, laws specifically mandate that no restriction shall cause 'substantial harm' to any lawful user of the water in question (Dunning 2003). As a result each proposed transfer must undergo the prolonged approval process and the water authority has the discretionary power to weigh the effects on other users and the environment against the benefits of the transfer. Facing the legislative dilemma wherein public and private interests are recognized as legitimate, and pressure from consumptive users, the state water authority has been often unable to provide sufficient protection of public instream interests (Dunning 2003).

Furthermore, limited transferability of private rights to use water resulted in diminishing market efficiency. Therefore, despite profound water scarcity, users in California continue to grow low-valued crops and are often engaged in wasteful use (Thobani 1997).

According to Andersen and Syder (1997), Kwasniak (2006) and Harris Consulting (2003) the possibility to lose unused water is another important factor potentially impeding market efficiency, diminishing the security of tenure and narrowing water management options by users, conservation in particular. Under prior appropriation doctrine water rights in California can be reduced or cancelled if water is not used as licenced.

In contrast to California, markets in Chile are characterized by strong property rights, broad private economic freedoms, and limited government intervention (Bauer 2004). The 1981 Water Code applies to the administration of water use in streams and the distribution of water to secondary channels and individual users. The Code handles private rights holders that form three levels of water users' associations (WUAs) (Donoso 2006). There are no restrictions as to purpose or manner of water use and users have complete freedom in the use of water, subject to their respective water use rights (Hearne and Donoso, 2005, Donoso 2006). Return flows can be used by recipients without the need to establish a right of use and are subject to flow availability and usage rates by the rights holders. Rights cannot be lost if water is not used, which coupled with transferring the ownership of infrastructure to WUAs, had strengthened the security of tenure and created private incentives for conservation (Donoso 2006, Hearne and Easter 1995).

Although formal markets have been active only in parts of Chile where water was a scarce resource, significant efficiency improvements of 20-26% were achieved in agricultural water use: 70% reduction in water use in wood pulp production and increased urban and rural water supply and sanitation coverage (Hearne and Easter 1997, Bauer 2004, de la Luz Domper 2009). One of the key components of the reform was delegating most of the decision-making power to water users, which relied upon the establishment of strong and freely transferable property rights (de la Luz Domper 2009). Despite widely recognized positive implications of free markets established under the 1981 Water Code, Hearne and Easter (1995), Rosegrant and Gazmuri (1995), Bauer (2004) and Donoso (2006) pointed out several disadvantages. They argued that the system in Chile was lacking environmental protection incentives and mechanisms enabling government to set the limits to water use in case of drought or any threats of severe environmental damage (Bauer 2004, Mentor 2001, Kraemer *et al.* 2004).

As demonstrated above, despite considerable difference in the extent of decision-making freedom by private users in California and Chile, both jurisdictions fell short of the mechanisms to reconcile public and private interests (Mentor 2001). The primary purpose of implementing water quantity markets in California and Chile was to reallocate scarce water resources between competing ends in a decentralized manner. In other words, all users that were allowed to purchase and hold private rights were capable of competing in the market. As illustrated by the California and Chile cases, markets resulted in better performance where stronger private property rights in water existed. Since in both cases the private sector was not allowed or otherwise motivated to hold private rights to instream flow, environmental interests were secured by government reservation and, therefore, not supplied by markets. Whereas technical efficiency has increased due to increased productivity of water and reallocation to higher valued uses, improving to some extent social benefits from water resource use, the overall benefits were not maximized as important public instream interests were largely undersupplied by markets.

Markets provide flexibility in allocation, and market-clearing prices force users to consider the opportunity cost of water resources; therefore, fairness between buyer and seller is implied as one would otherwise avoid the trading (Howe *et al.* 1986). It follows that stronger transferable rights to water are a prerequisite to improving water use efficiency and to secure water to other users by means of markets.

Property rights have long been governed by the principle "use your own property so as not to harm another" (Brubaker 1995). However, in a complex reality where uncertainties and a presence of multiple agents make it difficult to foresee damage, individual users would rarely account for such damage unless their responsibilities are as clearly defined as their rights. Therefore, establishing private responsibilities for public interests is crucial to securing the supply of those interests (Andersen and Snyder 1997, Rosegrant and Gazmuri 1995, Cantin *et al.* 2005).

In watersheds with multiple users and different types of polluters, water quality is an important public interest whereby the provision of clean water is a direct consequence of water allocation and water use (Andersen and Snyder 1997, Howe *et al.* 1986). Although other factors such as climate and precipitation influence the quality of water, water quality is directly related to water quantity for two main reasons. First, the ability of a water body to assimilate waste depends on the quantity of water available to dilute waste (Woodward and Keiser 2002, Andersen and Snyder 1997). Second, the quality of the water of a water body depends on the magnitude of the pollution resulting from water consumption (Andersen and Snyder 1997, Weinberg *et al.* 1993). In other words quantity and quality issues are interrelated to the extent to which quality is affected by the amount of water available instream and quantity and quality of the return flow. In this respect, establishing responsibilities for the impact on water quality resulting from exercising private consumption rights would be critical for an effective water allocation system. Considering the costs of water and wastewater treatment born by private users as a result of diminishing surface water quality, water quality is an important private interest compatible with public interests. Therefore, in order to yield maximal net social benefits an optimal water allocation system would integrate quantity and quality considerations (Andersen and Snyder 1997, Howe *et al.* 1986, Porto and Lobato 2004).

The next section examines the allocation of responsibilities for water quality among water users, incentives provided by various quality control systems to reduce pollution in response to changing water quality, quality requirements and willingness of users to pay for and maintain desirable water quality.

## 2.3 Institutions to regulate water quality

Approaches to regulate water quality include command-and-control and incentive-based instruments, similar to water allocation approaches, vary to the extent of decision-making power exercised by water users and regulating authority. The command-and-control approach is a typical example of a regulatory instrument that is decided and enforced by public powers. There are two types of instruments that represent the command-and-control approach in water pollution control systems - technology-based standards and performance-based standards.

Technology-based standards are uniform effluent “end-of-pipe” standards that are achievable using the best available pollution abatement technologies (Porto and Lobato 2004). Under this approach identified polluters are required to install specific abatement technologies that would yield the maximum pollution reduction achievable by these technologies. The performance-based standards specify environmental water quality objectives and require all identified and regulated sources in the watershed to attain this objective by establishing the total maximum amount of pollutants that can be discharged to the watercourse. Both technology-based and performance-based standards have proved effective in achieving substantial point source pollution reductions (Kraemer *et al.* 2004). However, the literature highlighted several disadvantages limiting the effectiveness of command-and-control measures, especially when point sources reach the limit of efficiency in maintaining compliance to specified standards (*ibid*, Tietenberg 1990, Woodward and Keiser 2002).

First, prescription of standard abatement technologies discourages investments in technological innovation because sources are not required to improve their performance beyond the capacity of the prescribed technology. Also, regulations disregard the difference in control costs across pollution sources and, as a result, responsibilities to reduce pollution loads might be distributed so that some sources face higher costs of reduction (Fassbender 1994). At the same time nonpoint sources that are largely unregulated and whose pollution reduction costs are lower, have no incentives to reduce pollution loads. As additional control requirements are imposed on point sources, reaching the limits of control efficiency, become prohibitively costly, and environmental water quality will decline if contribution from nonpoint pollution sources is significant (Woodward and Keiser 2002). This effect might be particularly significant in areas with large agricultural developments (Selman *et al.* 2009).

In contrast, incentive–based instruments use an array of financial incentives, such as taxes/charges, subsidies or markets to motivate a desirable behaviour and reduce pollution. Pollution or input taxes are widely used by the European Community countries, whereas the U.S. has increasingly made use of tradable discharge permits (TDPs), i.e. quality trading, to help achieve environmental quality goals (Howe 1994). Although widely used in the EU countries, consideration of political feasibility often results in taxes that are too low to have noticeable incentives (Howe 1994). Therefore, if, for example, input substitutes require larger investment than costs incurred by taxation, polluters would pay a tax and continue to pollute. Imposition of a pollution tax can be highly effective in preventing pollution from heavy individual polluters, but less effective where there is a need to reduce the pollution loads from a growing number of pollution sources as it does not set a limit to cumulative pollution (Howe 1994). At the same time pollution taxes do not constitute the least cost option and might discourage innovation. Also, lower cost effectiveness is argued to be another disadvantage of taxes and charges as compared to another incentive-based approach – markets for water quality (Howe 1994).

Water quality trading is a mechanism to increase water quality in a cost-effective manner through defining and assigning responsibilities to use water. According to Tietenberg (1990) a "well-defined pollution trading system can cost-effectively allocate the control responsibility for meeting a predefined pollution target among the various pollution sources despite incomplete information on the control possibilities by the regulatory authorities". Indeed, markets are triggered by the establishment of pollution reduction targets: e.g. water quality standards that require all sources collectively to achieve them in a given watershed (Selman et al. 2009). Regulators impose a pollution cap on the watershed where environmental water quality objectives are not met, i.e. the total amount of pollutants allowed in the watershed over time (*ibid.*, Eheart and Ng 2004). A pollution cap is set to reflect a set of conditions, such as water quantity and temperature, which determine the assimilating capacity of the water body (Howe 1994). Upon imposition of a cap, all point sources are allocated with their respective share of pollutants in the form of an effluent permit. A "good" thus defined by the effluent permit represents "concentrations of a pollutant based on the location and magnitude of the pollution" (Tietenberg 1990). Under this system, point sources depending on their costs of control, have several options ranging from improving their own facilities to purchasing additional permits from other facilities, or to invest directly in reduction equivalent from non point sources (Lal 2010, Eheart and Ng 2004).

To date quality trading has been implemented in watersheds where, despite high public and private costs, environmental water quality diminished, thus compromising the ability of users and the environment to satisfy quality needs (Woodward and Keiser 2002). The primary purpose of establishing a pollution cap has been to limit the flux of pollutants, mainly nutrients, to a watershed and reduce the impact on users with high quality requirements (Selman *et al.* 2009). Allowing trading in these cases served as a means to relieve a control burden by point sources, and in particular, sources with high control costs (Lal 2010, Fassbender 1994, Tietenberg 1990, Eheart and Ng 2004).

According to Tietenberg (1990), the magnitude of potential cost savings is very high if trading takes place between point and nonpoint sources due to significant difference in marginal control costs, an efficiency condition for pollution reduction. This happens because nonpoint sources have large potentials to reduce pollution and their reduction costs prove to be much lower than those of point sources. Therefore, where the impact from agricultural non-point sources was significant, municipal and agricultural users established point to non-point source trading programs, wherein municipal users invested in reduction from agricultural users (O'Grady *et al.* 2008, Lal 2010). Credits generated through reduction by non-point sources were used to offset pollution by point sources. Program designers established trading ratios that allowed the elimination of any distortions resulting from uncertainties in reduction by non-point sources. Trading ratios varied depending on the complexity of the reduction program, geographical conditions and resulting uncertainty. Ratios could range from 2:1 (two units of reduction from non-point source to offset one unit of pollution from a point source) to 4:1 (four units of reduction from non-point source to offset one unit of pollution from point source). In addition to considerably reducing control costs by municipal point sources, trading helped to reduce the overall stream of pollutants from otherwise unregulated or under-regulated agricultural non-point sources by creating monetary incentives to reduce pollution, thus improving environmental water quality (Selman *et el.* 2009) – the best outcome that coincides with the social objectives (Tietenberg 1990).

## 2.4 Combined water quality and quantity markets

The literature addresses the performance of various water allocation systems based on a variety and range of users' rights and responsibilities secured by each system. Literature reveals the difficulties inherent with each system of governance as a result of the fluid nature of water coupled with intersecting public and private interests. Intensive government oversight has been criticized for impeding water quantity markets' efficiency but has been so far justified due to the lack of legal instruments to safeguard other users and the environment from damages. However, negative effects can occur under any type of water governance regime (Andersen and Snyder 1997). Indeed, reduction in return flow can happen under any type of allocation system if more water-efficient technologies are adopted (Brennan and Scoccimarto 1999, Donoso 2006). Similarly, instream flow needs can be undersupplied under any type of governance regime, especially if water was historically allocated under a system of prior appropriation (Andersen and Snyder 1997, Johnson 1988, Kwasniak 2006). Instream flow needs are either not recognized as legitimate or secured through junior rights, whose supply is reducible to the needs of the senior consumptive rights. Where provision of instream flow is secured by a diversion cap imposed by government, this reservation if established after the basin became overallocated, is often minimal and therefore insufficient to satisfy instream needs (Kwasniak 2006, Wenig *et al.* 2006, Jillilan and Brown 1997, Andersen and Snyder 1997). Damage to third parties, e.g. diminishing water quality, can be equally a result of water transfers, increased consumption by existing users or unregulated pollution by non-point sources.

Considering that neither government regulation nor markets can alone safeguard all users from damages, the desirability of each approach under certain conditions can be assessed against its ability to achieve the highest aggregate benefits (Howe *et al*. 1986). Although literature has not documented empirical observations, few theoretical studies have mentioned benefits of conjunctive water quality and quantity management, coupling water quantity and quality markets in particular.

Brubaker (1995) argued that where property rights to the resource are clearly defined, then whoever values the resource more will end up with the resource. It was posited that the definition of users' rights and responsibilities would ideally reflect users' expectations about the state of the resource and perceptions of potential damage (Howe *et al.* 1986, Brubaker 1995). Brewer *et al*. (2007), and Weber (2001) have emphasized the willingness of users to pay for better water quality, and that location-specific difference in water quality might influence water pricing in the market. Howe *et al.* (1986) suggested including within water licences the description of the water quality of which users are entitled. The quality could be enforced through the establishment of maximum attainable environmental water standards, which could be achieved only if enforced of all water users in the watershed. Howe *et al.* (1986) and Andersen and Snyder (1997) articulated that where rights to clean water cannot be otherwise defined, the pollution cap and a system of tradable pollution rights have the potential to facilitate the achievement of an established water quality standard.

Furthermore, a body of literature emphasized the effect of diminishing return flow on water availability to some users, but very few mentioned its potential impact on source water quality. Indeed, where return flow originates from irrigation, whose polluting effect is widely recognized, its impact on receiving water quality and associated damages to other users might be significant if this water is allocated for stock-watering or drinking water for human consumption (Weinberg *et al.* 1993, Johnson 1989). The severity of the effect depends on the amount of water originally diverted and consequently returned to the stream (Woodward and Keiser 2002). Considering that agricultural sources are nonpoint sources and therefore unregulated, additional costs borne by municipal users include meeting strict regulations to reduce pollution from municipal wastewater and to improve surface water quality.

Weber (2001) argued that the optimal outcome from resource allocation could be achieved by coupling a market for water quantity and quality in the watershed where both dimensions of the resource are scarce. According to the model developed by Weber (2001) a market for water quantity coupled with a quality market internalized impacts on water quality. The level of water quality depends on both surface flows and discharge magnitude and the effect of return flow increases downstream as a result of the consumption and decreased streamflow upstream. The changing value of the water as its quality changes is reflected by its market price.

At the same time users are held responsible for changes in water quality by maintaining the assigned location-specific discharge loads, with control costs reflecting water quality at a spot resulting from stream's assimilating capacity. The location specific environmental water quality and quantity are then reflected by prices for water licences and pollution permits. Where both dimensions of a water resource (quantity and quality), have a price the users and polluters face the real cost of using the resource and can flexibly adjust quantities consumed or discharged.

If water is a scarce resource and environmental quality is a constraint, establishing quantity and quality markets in parallel could constitute a model that would satisfy the criteria for an optimal resource allocation system, i.e. a system that is efficient, perceived by users as equitable and one that creates incentives for conservation. Allocation by market instruments assumes that there is a limit to water consumption and rights to use the existing supply should be reallocated between users in accordance with the marginal value of water in each use. Where environmental water quality is a constraint and there is a need to improve environmental water quality and reduce pollution from multiple sources, including previously unregulated nonpoint sources, pollution markets prove more effective and less costly. A pollution cap represents a limit to pollution and calls for a need to reallocate responsibilities in accordance with values and costs of pollution to each user.

Where there is a demand both for high quality water and pollution, markets meet the efficiency criteria by allocating both water and pollution to their highest-value uses. Users make decisions in response to incentives from changing resource quantity and quality. Incentives generated by markets, i.e. market-cleared prices that reflect the value of water and pollution, ensure that users take into account the real opportunity costs of water resource uses.

Markets can create incentives for conservation as environmental water quality improves as a result of pollution reduction efforts by all sources. Legitimizing private instream flow rights and allowing private sector water users to hold rights to instream flow for improving stream's assimilating capacity might create even stronger incentives for conservation and improve water quality further (Andersen and Snyder 1997). A pollution cap represents the limit to pollution and consumption as it is derived from the function of current assimilating capacity of a stream (Howe *et al.* 1986). Where a diversion cap is ineffective in supplying water for instream flow due to resistance from consumptive users to give up water, then, considering the interrelatedness of quantity and quality, a pollution cap can set a limit to consumption by creating private incentives to leave more water instream. Allowing private rights to instream flow might as well improve the efficiency of allocation by water markets as environmental values will be included into competition for water (Andersen and Snyder 1997). Polluters could offset pollution by acquiring private rights to equivalent volume of instream flow necessary to enhance assimilating capacity of the stream (Andersen and Snyder 1997). In addition to improving water quality, this practice might benefit other instream flow users such as people engaged in fisheries or recreation, by maintaining sufficient streamflows, reduced effect from eutrophication and improved aesthetics.

There are a number of conditions that might trigger institutional change. Since markets can only allocate a resource efficiently if it is in short supply, water scarcity and diminishing quality are the main conditions for implementing water quantity and quality markets. Another condition is the existing or emerging demand for higher-quality water, (for personal consumption) and the evident impact on water quality by other users (agricultural). Also, market prices for water rights and pollution permits depend on opportunity costs resulting from the use of water and/or magnitude of pollution reduction costs. Therefore, heterogeneity of users and polluters, i.e. the presence of users with varying technological and economic potential, is another condition that triggers the implementation of markets.

Research shows that water quantity and quality markets administered in parallel, could help to improve the efficiency of water use and water quality. This would work best in a region where government regulation fails to reallocate rights and responsibilities related to water use, and where traditional water allocation systems create resistance to change in spite of growing demands. Regardless of water quality and quantity, change from one administrative system to another would likely result in resistance by some users. To test the likelihood of transitioning from a command-and-control-type system to a market-based system that includes quality and quantity elements, it is important to select a study area with evidence of increasing demand for water and increasing pollution. Additionally it will be important to assess users' perceptions of both water quality and quantity, satisfaction with the current water administration and the acceptance of water markets in general.

# 3 METHODOLOGY

This section describes the research methods used to assess stakeholders' perception about water resource status in the SSRB and the performance of existing and proposed systems of administration to maintain water users' rights and responsibilities in the region. It includes several sections that (1) describe the study area according to key characteristics related to water availability and use (2) the survey instrument used to examine stakeholders' perceptions, and (3) survey methodology using the z-scored statistical method (ZEF) and (4) sampling methods.

## 3.1 Study area description

The area selected for this study was within the SSRB (Figure 3.1), a large watershed in southern Alberta known for its historical water scarcity, emerging issues with water quality and where water was traditionally allocated under the system of prior allocation, recently supplemented by market regulation.

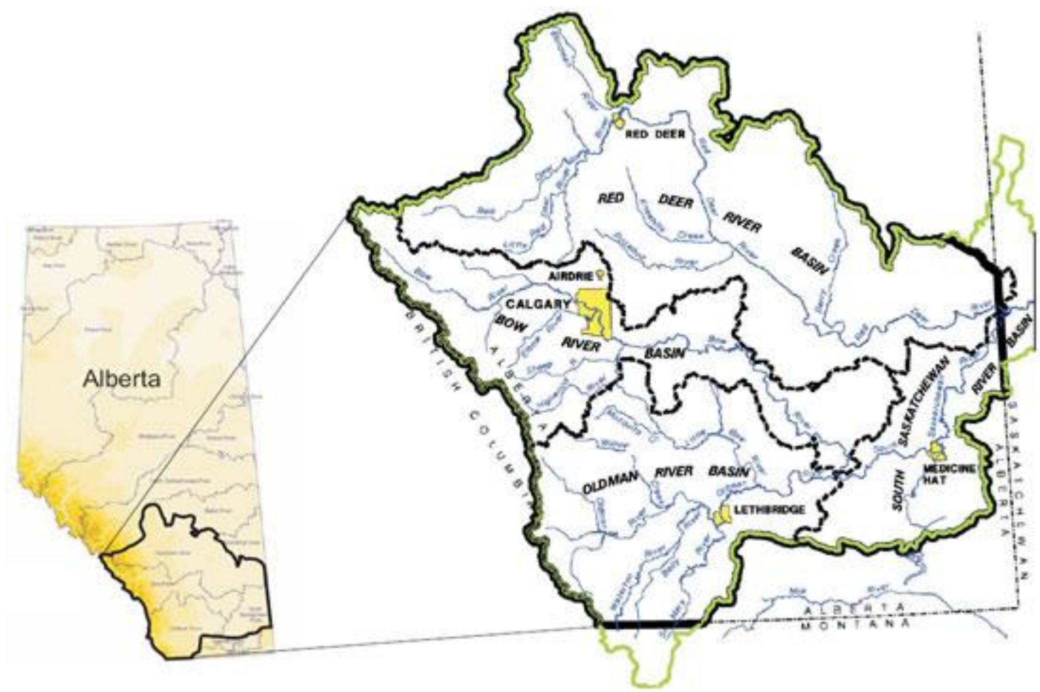


**Figure 3.1 South Saskatchewan River Basin (adopted from: Alberta Environment 2005)**

The proposed case study was aimed at examining stakeholders' perceptions about the resource status and the ability of the existing and proposed systems of water administration to maintain rights and responsibilities pertaining to the use of water. The obtained results were used to assess the acceptability of water quality markets and possible institutional barriers to implementation.

Alberta has only 2.2% of Canada's renewable freshwater, of which only 10% is available in the south where 90% of Alberta's 3.5 million population resides (Christensensen and Droitsch 2008, Vander Ploeg 2010). Only 3% of water withdrawn in Alberta comes from groundwater. Most of the freshwater supply depends on variable and unpredictable flows in rivers. Additionally, the population is expected to increase by 40% in the next 20 years with an estimated increase in water consumption of 25% by 2020 (Vander Ploeg 2010). The impact from climate change is also likely to decrease water availability by 7-10% by 2020 (Maas and Telfer 2007). The SSRB with its three major tributaries – Oldman, Bow and Red Deer rivers – constitutes the main source of water supply in Southern Alberta. Almost 60% of all water allocations in the province are held within SSRB, and 80% of all water consumption occurs. Industrial allocations account for 3% and are held mainly by oil and gas companies in the Red Deer sub-basin, where 70% of all industrial allocations in the SSRB are found. The municipal sector holds 11% of all allocations, of which 75% are found in the SSRB (Vander Ploeg 2010). The South Saskatchewan River alone accounts for 60% of allocations for municipal use. Over 97% of all provincial agricultural allocations are held within the SSRB. Of this, over 96% of all water is used for irrigation, with the remaining 4% used for stock watering. Although more than 20,000 licences have been issued since 1894, approximately 75% of the water is tied to fewer than 20 of the licences issued to 13 irrigation districts located between Calgary, Lethbridge and Medicine Hat (Christensensen and Droitsch, 2008). Furthermore, the agricultural sector is the largest water consumer in Alberta and accounts for more than 95% withdrawal and consumption. Allocations in the South Saskatchewan River sub-basin are very much dependent on water consumption that takes place in the Bow and Oldman rivers (Van Ploeg 2010). Figure 3.2 shows sectoral water allocations in the SSRB.

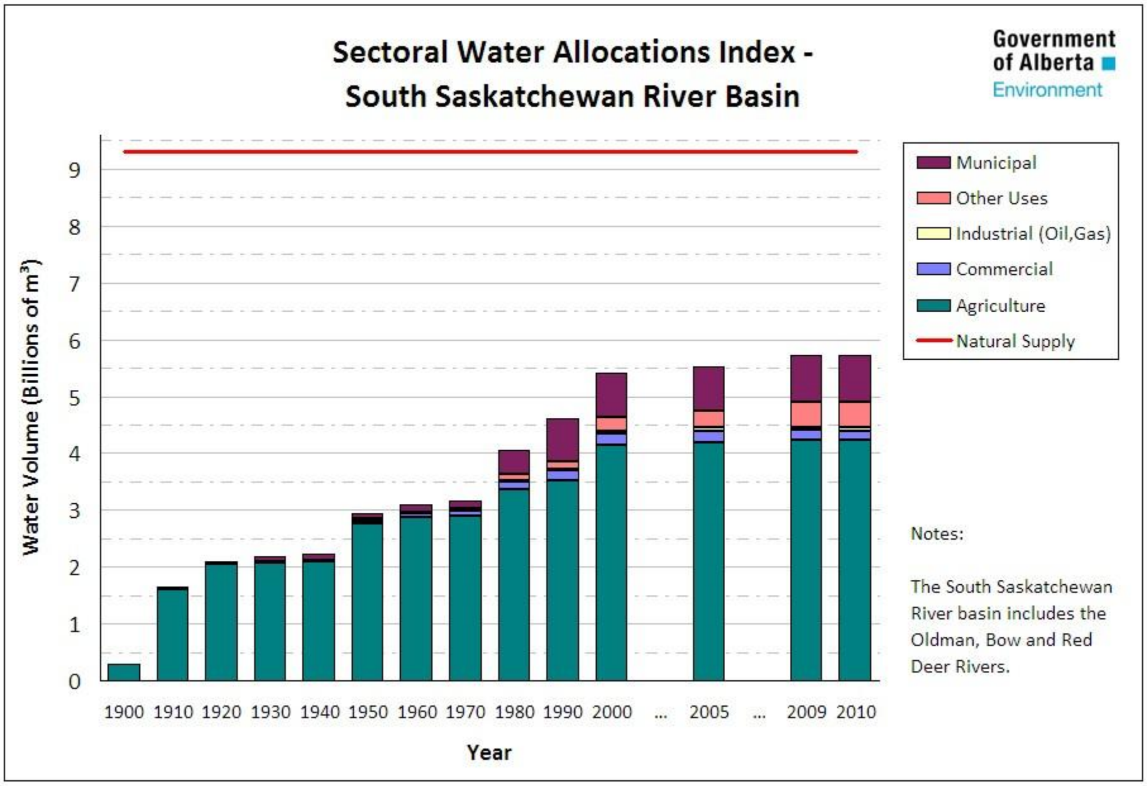


**Figure 3.2 Sectoral water allocations in the SSRB (adopted from: Alberta Environment 2010)**

Water is administered in Alberta through combination of government regulation of water quantity and quality and markets that are used to transfer water licences. In the late 1990s due to water shortages the Bow, Oldman and South Saskatchewan rivers were closed to further allocations. Following the suspension, the Alberta government authorized allocation by market regulation and revised the Alberta Water Act and Alberta Irrigation Act accordingly. Among the primary reasons for administering a market system was the need to reallocate water from existing uses into emerging uses and to improve the efficiency of water use. Transfers within irrigation districts are now regulated by the Irrigation Districts Act (2000), performed in an informal manner by mutual agreement without oversight by external authority (Vander Ploeg 2010). The Alberta Water Act, S.82 (1999) allows water transfers of all or part of a licenced allocation from the existing licencee to new users provided that such a proposed transfer does not result in any damage to the rights of other users and aquatic environment. The Alberta government designated Alberta Environment to supervise all transactions that involve a transfer of all or part of a licence

(Percy and Weber 2010). According to the legislation, the provision and protection of instream flow interests has become a responsibility of the provincial government. Under the Alberta Water Act, S.81 (1999) Alberta Environment is required to establish water management plans for each basin, which would specify appropriate conservation objectives based on estimated minimal streamflow requirements. The appropriate conservation objectives, where they are established, guide the decisions of a designated authority about water licence allocations and proposed transfers.

Within the study area point source pollution is strictly regulated and, therefore, impact is minimal from municipal and industrial sources. However, there is no regulation that would effectively control or prevent the pollution from agricultural non-point pollution (Matisz *et al*. 2010). Growing cities and resulting urban runoffs represent a challenge for regulators and pose a threat to surface water quality (Vander Ploeg 2010).

Because of these factors, the area is ideal to test perceptions regarding resource status (water quality and quantity), perceptions about performance of the current administration and likelihood of adopting a new administration, i.e. water quality markets.

## 3.2 Survey instrument

A questionnaire was developed and implemented to assess stakeholders' perceptions of current and a proposed water resource allocation approaches. The instrument was approved by the University of Saskatchewan Ethics Review Board.

The survey consisted of three sections, each addressing the respective research objective:

1. To evaluate stakeholder perceptions of the current resource status (scarcity/quality)
2. To evaluate stakeholders' perceptions of the current resource administration including their experience with water markets
3. To evaluate the willingness to adopt a proposed water quality market mechanism

Following the short introduction and description of the research project respondents were offered a choice to agree or disagree to participate in the survey (see Appendix A). Those who agreed were offered three groups of questions.

In the first section respondents were requested to share their perceptions about water scarcity and quality at their locations. They were also offered the opportunity to indicate the extent to which their current and future needs in water were satisfied. The following set of questions addressed the possible causes of diminishing water quality and declining water supply. Users were requested to indicate the extent to which the pollution sources contributed to the pollution of surface water.

The second group of questions solicited stakeholders' perceptions of the current water administration including their experience with water markets. Under the current administration access to water can be secured by purchasing licences in the market. Government no longer allocates water but retains control over allocation by supervising transfers, establishing flow requirements and regulating water quality. The current administration specifies how rights to use water are exercised and the responsibilities for pollution abatement. Questions in section two were structured so as to assess the relative importance of such rights and responsibilities to users and the performance of the existing system in provision of these services.

In the third section, upon provision of a brief description of the proposed system, respondents were offered a chance to consider the changes that proposed system, i.e. imposition of a pollution cap and establishment of tradable discharge permits, would induce on their current rights and responsibilities and to indicate their agreement or disagreement with the proposed system.

### 3.3 Survey methodology

The assessment of stakeholders' perception about the adoption of proposed water governance systems was performed through an online stakeholders' survey developed specifically to collect and analyze electronic data. The results of the survey were analyzed using z-scoring, a statistical technique performed by ZEF (Z-scored Electronic Feedback) software. Z-scores are standardized deviations from their means and always have a mean of zero and a standard deviation of one. The standardized or normalized values provide a way of comparing the results without opinion distortion.  The example below shows the typical absolute (a) and processed normalized (b) survey results.

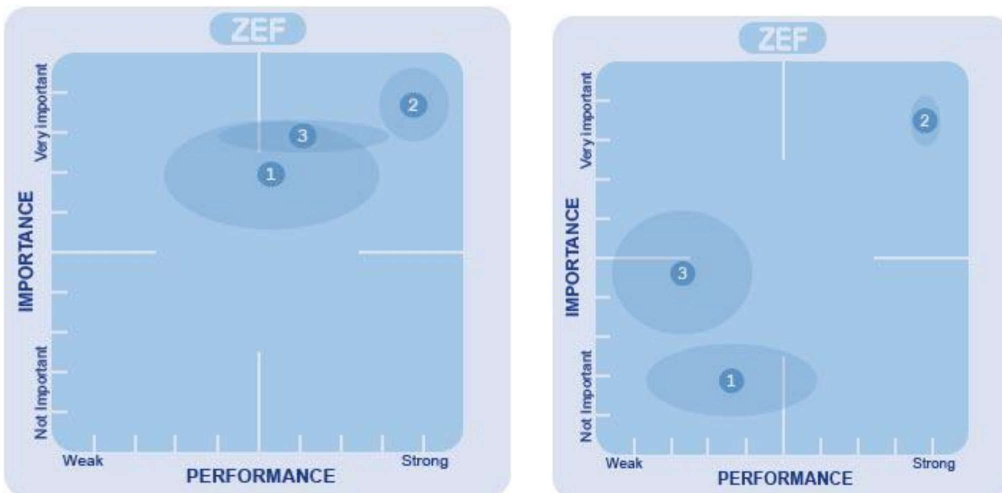


**Figure 3.3 (a) Absolute results (b) Normalized results**

**Adopted from: http://kysy.oamk.fi/zef/docs/zef-method-en.pdf**

Figure 3.3a and 3.3b show the absolute and normalized results of responses based on two criteria: performance on the x-axis and importance on the y-axis.  The absolute results (Figure 3.3a) reflect the average response scores reported according to responses as marked directly by survey respondents on the two-by-two grid. Normalized values (Figure 3.3b) are calculated using z-scoring whereby the distribution is centered so that the mean value is zero. Standard deviations are shown by shaded areas.

The strength of this method is reflected in the interpretation of the normalized responses by quadrant.  Whereas standard survey methodology asks one question, the grid method provides a richer palette of responses and allows relative ranking of results in relation to each other.

### 3.4 Sampling

The SSRB study area in southern Alberta included four sub-basins – the Bow, Red Deer, Oldman and South Saskatchewan rivers. Sampling took place randomly across sub-basins. The surveyed population targeted three groups: (1) agricultural, including representatives from irrigation districts, (2) municipalities, composed of municipal water/wastewater managers (including the four largest cities in the watershed: Calgary, Lethbridge, Red Deer and Medicine Hat, and (3) others, which included views of the provincial government, NGOs and representatives from the academic community. Municipal and agricultural water users represent two large groups of water users that hold the largest number of private water licences and, therefore, have greater influence on water use, and as a consequence, on water availability and quality. The majority of transactions within water markets occurred between these two groups. Similarly, implemented water quality trading took place either between municipal wastewater treatment facilities or through a form of offsets acquired by municipal users from reductions by non-point agricultural sources. The survey was distributed to senior-level water managers in both groups based on the assumption that they would have been knowledgeable about water/wastewater treatment costs and costs of improving water use efficiency and/or pollution reduction costs by non-point sources.

The participation of the academic community provided additional background for the assessment of stakeholders' perceptions from a broader economic and legal perspective. Views from regulatory authorities helped to understand the position of the government with regard to the existing and proposed systems. The purpose of recruiting respondents beyond municipal and agricultural sources was to allow for the inclusion of interests by a diversity of water users. It was decided not to include the general public because survey questions aimed primarily at examining perceptions about private rights and responsibilities and focused on responses by private agents to proposed policy changes. Respondents were requested to answer only relevant questions. The last section of the survey included demographic questions, such as age, gender, education and income. In this section respondents were also requested to indicate their location in the watershed to facilitate the correlation of responses to potential impacts on water availability and quality.

Survey participants were selected using a public directory listing the contacts of Alberta municipal water authorities and irrigation districts. Participants were invited to complete the survey and were also asked to recruit interested parties.

The survey was pretested on 47 individuals involved in researching various water-related issues at the University of Saskatchewan. The survey was modified accordingly and the final survey instrument was emailed to potential respondents.

# 4 RESULTS

This chapter presents the survey results beginning with a description of response rates, licence holders and trading experience. The next three sections focus on stakeholders' perceptions about resource status and the current and proposed systems of administration. The chapter concludes with the results of a hypothetical referendum and demographics.

## 4.1 Response rate

The Internet survey was open for three weeks (from April 7$^{th}$ to April 30$^{th}$, 2013). After the initial invitation, two reminders were sent a week apart to increase the response rate. A total of 200 invitations were sent to three groups including:

- Municipal water supply/wastewater – 127 individuals
- Irrigation districts – 8 individuals
- Others (academic, regulatory, NGOs) – 65 individuals

The total number of responses received was 40 giving an overall response rate of 19.1%. According to self-identification there were 16 municipal participants, two from irrigation districts, and 22 respondents in the "others" category, including academic, regulatory, NGOs and First Nations.

Since the survey sought to assess views on water markets, it was important to ask if respondents held licences. Seventeen respondents (50.0%) stated that they did not hold water licences. Of those respondents who did, 13 (38.2%) held transferable licences; two (5.9%) had licences that were not transferable, and two (5.9%) were not sure if their licences were transferable Figure 4.1. In addition, 30 respondents (88.2%) did not have experience participating in water trading, whereas only five respondents (14.7%) participated indicating they were buyers.


**Figure 4.1 Respondents with transferable licences**

## 4.2 Perceptions of the current resource status

Questions in this section focused on stakeholders' perceptions about current water resource status. This section was divided into questions pertaining to water quantity and water quality. Respondents were first requested to indicate their agreement with the statement: "Water is becoming more scarce." More than half of the respondents (n=24; 68.6 %) agreed that water is becoming scarcer; whereas eight respondents (22.9%) disagreed and three respondents (8.6%) were not sure (Figure 4.2).


**Figure 4.2 Perceptions about water scarcity**

In follow-up questions, respondents rated their ability to secure access to water and the extent to which water is available to satisfy their needs. Normalized responses are illustrated in Figure 4.3 with the standard deviation indicated by the shaded area around each number. The question numbers correspond to the numbers in Figure 4.3.

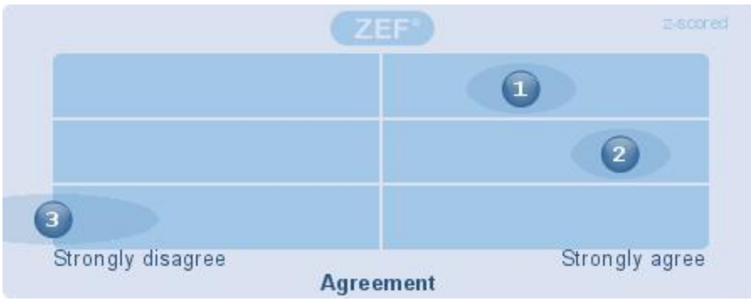


**Figure 4.3 Security of access to water**

(1) I have secure access to water (n=25)
(2) I have sufficient water for my needs (n=23)
(3) I have the ability to secure water licence (n=23)

Respondents strongly agreed with their ability to maintain secure access to water (1) and that they could satisfy their current needs in water (2). Although it appears that the majority of respondents did not agree that they have the ability to secure water licences (3), opinions were more varied as indicated by a greater standard deviation. Respondents were also asked to provide additional remarks about issues related to water availability and supply of which 15 commented. Several respondents pointed out that the watershed had been closed for new allocations, and that licences could be secured only through water markets. According to participants' comments, water availability varies by location in the watershed. In general, water was perceived to be available for most uses, including municipal, where most municipal licences could satisfy potential future growth. Notwithstanding, respondents agreed that water is becoming increasingly scarce and that demand is growing steadily. Water quantity was regarded as a big concern by an Alberta First Nations person, and not sufficient to satisfy the instream flow needs. Finally, one respondent mentioned the importance of private rights to instream flow.

A second group of questions focused on surface water quality. The first question addressed stakeholders' perceptions about water quality. Respondents were asked to indicate their agreement with a statement that surface water quality is diminishing (Figure 4.4). In total, 34 people responded and more than half agreed that quality was decreasing (n=20; 58.8%). Nine respondents disagreed (26.5%) and five were not sure (14.7%).

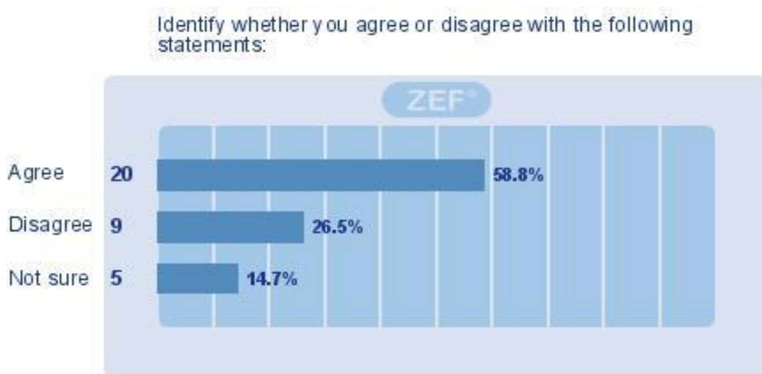


**Figure 4.4 Perceptions about water quality**

Participants were also asked to provide their perceptions of pollution sources specified by the following statements. The normalized responses are shown in Figure 4.5.

(1) Municipal water is polluting surface water (n=23)
(2) Industrial water is polluting surface water (n=23)
(3) Agricultural runoff is polluting surface water (n=23)
(4) There is not enough water instream to assimilate waste in surface water (n=23)

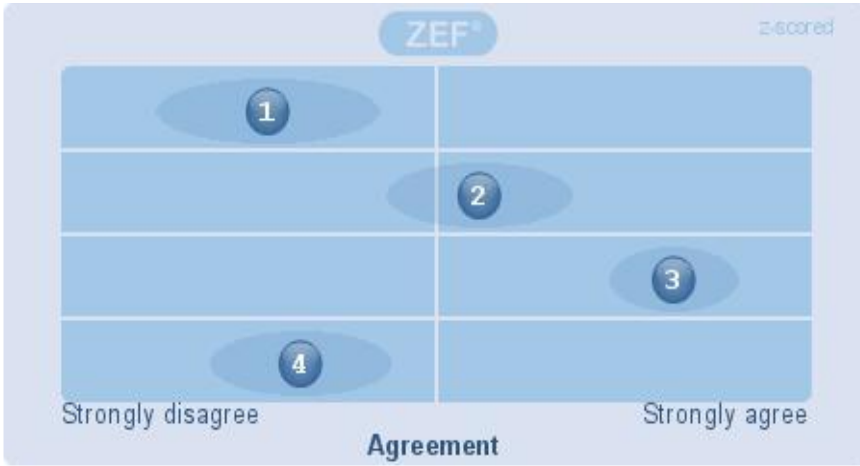


**Figure 4.5 Opinions about pollution sources**

Results suggest that the highest number of respondents strongly agree that agricultural runoff is polluting surface water (3). Similarly, there is little variation regarding the response as evidenced by the standard deviation. Opinions about other pollution sources varied across respondents. However, participants moderately agreed that industrial sources are a source of pollution (2), second to agricultural runoff. They generally disagreed that municipal wastewater contributes to the pollution of surface water (1). Also, the majority of respondents disagreed that pollution was a result of an impaired ability of a stream to assimilate wastes due to the lack of water (4).

Thirteen participants provided comments on water quality in the region. Respondents (n=3) commented on issues associated with prevailing pollution by agricultural non-point source pollution, which is consistent with the overall perception that agriculture is the main source of pollution out of the four presented. Respondents (n=2) pointed out that continuous improvements to municipal wastewater treatment facilities are being implemented in order to comply with regulations and to keep municipal discharges within established limits. One respondent suggested contamination from large cities e.g. Calgary and Lethbridge, was a contributing factor. Two participants related the extent of surface water pollution to the flow level, and emphasized increased treatment efforts (n=1) by municipal water supply services to meet potable water standards when flows are low.

## 4.3 Perceptions about the current water administration

Respondents were provided with a brief description of the current system of water administration (the status quo) and were invited to answer questions about the ability of the current system to secure rights and responsibilities related to water access and water use. Two questions were asked simultaneously: importance measured on the vertical access and the current administration's ability to provide such rights – measured on the horizontal access.

The section was composed of 10 statements about the current system. Figure 4.6 summarizes the normalized results using the z-scoring method with each number on the graph corresponding to the numbered statement.

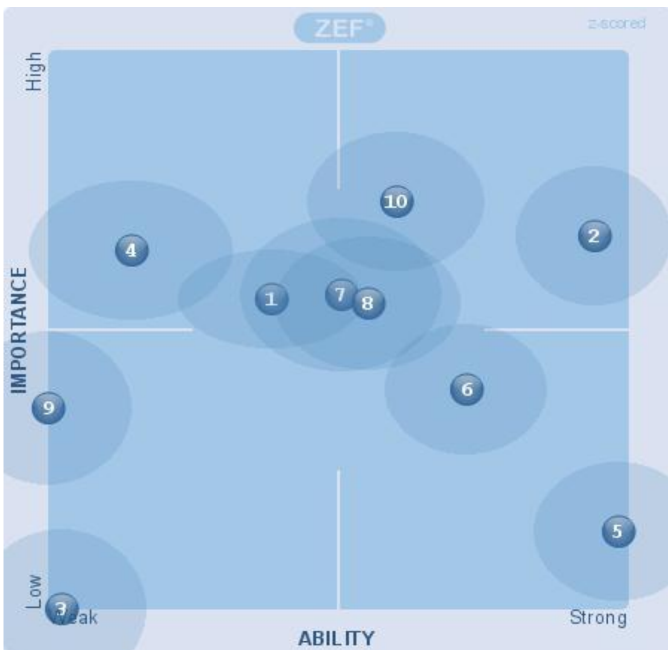


**Figure 4.6 Perceptions about current administration**

**(1) The ability to satisfy water quantity needs (n=29)**

**(2) The ability to provide high water quality (n=28)**

**(3) The ability to transfer the licence (n=28)**

**(4) The ability to secure/renew the licence even if water is not used (n=28)**

**(5) The ability to uphold the position of the licence in a first-in-time-first-in-right system (n=27)**

**(6) Enforcement of regulations to maintain water quality (n=27)**

**(7) The ability to secure long-term access to water (n=27)**

**(8) The ability to hold municipal polluters responsible for water pollution (n=27)**

**(9) The ability to hold agricultural polluters responsible for water pollution (n=27)**

**(10) The ability to hold industrial polluters responsible for water pollution (n=27)**

As reported in Figure 4.6, answers registering in the upper right quadrant indicate that respondents felt that rights and responsibilities were both important and that the current administration had the ability to deliver. This included providing water quality (2), holding industrial polluters responsible for their share of pollution (10), and the ability to enforce relevant regulations on municipal pollution sources (8). The normalized results are also consistent with open comments provided by some respondents.

The upper left quadrant is important in that respondents perceive rights to be important, but believe that the current administration has a relatively weaker ability to ensure such rights. Three responses were registered including the system's ability to maintain a secure water supply (1), the ability to secure/renew licences for unused water (4), and ensuring long-term access to water (7).

Results registered in the lower quadrants indicate that respondents felt rights were relatively less important. In one case, in spite of low importance, respondents believed that the current administration has a relatively strong ability to protect the system of seniority "first-in-time-first-in-right" FITFIR (5) and enforce pollution control regulations (6) where the latter was considered to be relatively more important.

The lower left quadrant indicates both the perceived relative inability to provide rights and the relatively low importance to respondents of such rights. Two issues include enforcing pollution control regulations on agricultural non-point sources (9), and licence transferability (3). Agricultural pollution control was ranked considerably higher in importance than transferability. It is important to reiterate that rankings are relative and that transferability (3) for example was not ranked absolutely at zero on both scales.

Ten respondents provided comments on the current system of administration. Six respondents remarked on pollution control from non-point sources suggesting pollution by point sources is strictly regulated (n=3), although one respondent pointed out that the system is becoming less efficient due to continuous population growth. Four respondents emphasized low effectiveness of the system in administering water licences transfers. According to some (n=3), the system is challenged by balancing environmental responsibility and meeting non-environmental interests in water. One respondent pointed out that new allocations under the current system were not issued in order to save water for future needs and that transfers of unused licenced volumes were not permitted and unused water was subject to cancellation.

## 4.4 Perceptions about the proposed system of administration

The proposed scenario suggested that the Government of Alberta would introduce a pollution cap as specified in the survey instrument:

> <u>*Proposed Water Administration:*</u> *the Government of Alberta could introduce a pollution cap that specifies the maximum amount of pollution allowed into a water source. The sum of all permits would account for the total allowable quantity of a specified pollutant in a water source (as specified by the "cap"). Those who wish to discharge more pollutants (for example those arising from nutrients such as phosphorus and nitrogen) would be required to purchase additional permits.*
>
> *Where implemented, quality trading markets created incentives for previously unregulated pollution sources to reduce pollution. A pollution cap will result in higher compliance costs in the short run for some polluters who can be identified. Under the proposed system, polluters with high compliance costs lower their costs by purchasing permits from sources with lower compliance sources. Thus, the proposed system promotes equity in pollution abatement. In general, water quality markets create incentives to reduce pollution and improve environmental water QUALITY.*

Respondents were asked to provide their perceptions of the proposed system's ability to address the same issues using the same scale of ability and importance. Results are compared against the results for the current administration as illustrated in Figure 4.7. The letter "E" represents the overall average of all responses in blue for the current water administration and the letter "F" represents the overall average of all responses in red for the proposed administration. Black arrows are used to illustrate shifts in stakeholders' perceptions between the current (blue) and proposed (red) administrative systems.

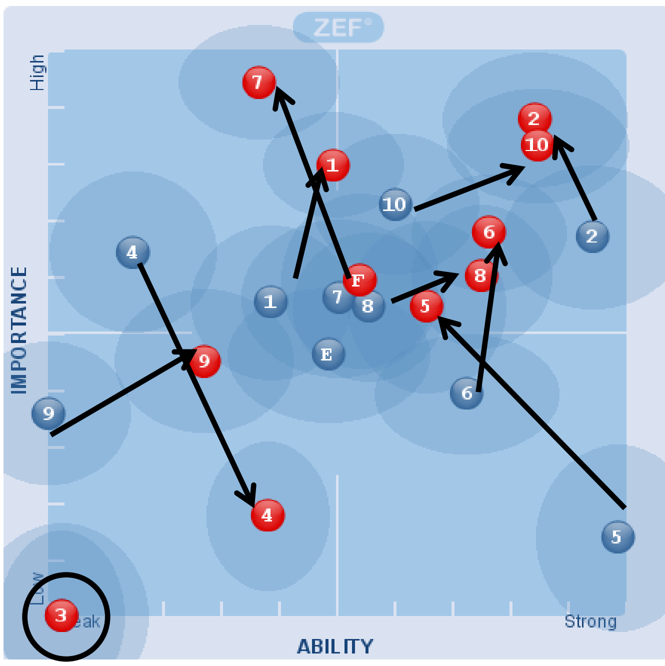


**Figure 4.7 Perceptions about proposed system of administration**

**(1) The ability to satisfy water quantity needs (n=26)**

**(2) The ability to provide high water quality (n=26)**

**(3) The ability to transfer the licence (n=26)**

**(4) The ability to secure/renew the licence even if water is not used (n=26)**

**(5) The ability to uphold the position of the licence in a first-in-time-first-in-right system (n=26)**

**(6) Enforcement of regulations to maintain water quality (n=26)**

**(7) The ability to secure long-term access to water (n=26)**

**(8) The ability to hold municipal polluters responsible for water pollution (n=26)**

**(9) The ability to hold agricultural polluters responsible for water pollution (n=26)**

**(10) The ability to hold industrial polluters responsible for water pollution (n=26)**

Respondents' ranking of eight out of ten characteristics shifted upwards on the importance axis. Similarly, the ability of the system under the proposed scenario to maintain sixty percent of the rights and responsibilities has improved relative to the current system with three weaker and one unchanged.

The importance of renewing licences for unused water (4) has decreased, and the ability of the proposed system to maintain a renewal of these licences is still very low but slightly improved. Respondents rank higher the importance of satisfying and providing water quantity (1) and quality (2). Respondents' ranking of the system's ability to maintain water quantity needs is still rather low under the proposed system but water quality needs are satisfied but to a lesser extent. Importance of ability to secure long-term access to water (7) has increased but the ability of the system to maintain the access has diminished further. However, the importance of pollution control regulations and the ability to enforce the regulations (6) increased. Respondents did not perceive that licence transferability (3) would improve under the proposed system. However, the proposed system's ability to uphold licencee's positions in a FTFR system (5) diminished although the importance of the seniority system increased.

As expected, the proposed system induced changes in perception regarding pollution control enforcement across sources (6). Performance improved with industrial (10) and agricultural sources (9), although agricultural pollution still posed a challenge and there was no significant difference regarding regulation of pollution from municipal sources (8) between the current and proposed systems.

Seven respondents commented about the proposed system of administration. Three respondents pointed out that the proposed system would be unable to deal with water availability/supply issues. One respondent mentioned legal constraints that limit flexibility, e.g. the possibility to lose water if it is unused. Four respondents argued that non-point sources would still pose a challenge. One respondent questioned the ability of a market instrument to deal with water pollution properly and mentioned the efforts of the Alberta government to develop programs that have better potential to reduce pollution than do market-based instruments.

## 4.5 Voting for the proposal

Finally, respondents were offered the opportunity to vote for or against the proposed system. It was suggested that the proposal would pass if 51% of voters were in favour. Twenty-two respondents voted: the results of the hypothetical referendum are shown in Figure 4.8.


**Figure 4.8 Results of hypothetical referendum**

While the greater number of respondents (n=9) voted in favour of the proposed administration, the proposal did not pass with only 40.9% of the 51% required. Six respondents voted against the proposal (27.3%, n=6); and seven were not sure (31.8%,). Four respondents who voted against the system explained their positions:

(1) The current system is sound.
(2) Water needs to be monitored at a higher level of authority where that authority takes into account all factors in a watershed.
(3) Too important to be less than 66%
(4) No referendum could be held unless adequate information is provided.

## 4.6 Demographics

Only 24 respondents answered the demographic questions. Half of those respondents self-identified as "municipal" (n=12), followed by "other" (41.7%, n=10) and "agricultural – irrigation" (8.3%, n=2) (Figure 4.9).


**Figure 4.9 Respondents self-identification by user group**

The largest proportion of respondents fell into the age group of 41-60 (59.1%; n=13), followed by 26-40 (22.7%; n=5) and 61+ (18.2%; n=4). The majority of respondents were men (69.6%; n=16), women accounted for 21.7% (n=5) with two respondents preferring not to reveal their gender.

Regarding education, the majority of respondents completed a Master's degree (56.5%, n=13), followed by a bachelor's degree and trade school (13%, n=3 in each group), one respondent had a PhD (4.3%), and one respondent completed K-12 (4.3%). The remainder preferred not to say (8.7%).

Information about income was provided by 23 respondents, of which six (31.6%) preferred not to answer, four respondents (21.1%) fell within the $30,000-59,999 range; one respondent (5.3%) fell within the $60,000-79,999 range; four respondents (21.1%) fell within the $80,000-99,999 range; and four respondents (21.1%) reported income equal to or above $150,000.

The majority of respondents self identified as urban (n=14; 63.6%), and eight as rural (36.4%) (Figure 4.10).

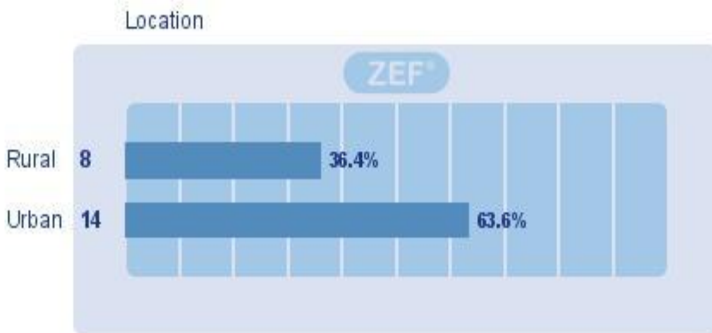


**Figure 4.10 Respondents self-identification by location**

Several respondents indicated the nearest city to them by sub-basin including:

- Bow river sub-basin:
  - Cochrane (n=1), Calgary (n=4), Okotoks (n=1)
- Oldman river sub-basin:
  - Lethbridge (n=4), Vauxhall (n=1)
- Red Deer river sub-basin:
  - Irricana (n=1), Hanna (n=1), Sundre (n=1)

The sample did not reflect the general population and therefore, results do not reflect general perceptions but rather the perceptions of specific groups of water managers.

# 5 DISCUSSION AND CONCLUSIONS

## 5.1 Response rate

The results obtained from the survey allowed me to examine the perceptions of different groups of stakeholders about the potential to implement the proposed conjunctive water administration system using markets for pollution. The main group was composed of agricultural (irrigation) and municipal users that represent private interests in water. Respondents in the "municipal' group were composed of water managers from 16 municipalities and regional water supply services including the City of Calgary and the City of Lethbridge, both of which are providing water to a large number of communities in the region. Two out of eight irrigation district managers provided responses in the "agricultural" group. The insufficient representation from this sector did not allow me to conduct proper statistical analysis and, therefore, research is lacking perceptions from this category. Respondents in the "other" category were composed of legal academic and government participants and provided insight based on the broader perspective of professional knowledge and public and private interests in water. Considering that respondents were requested to answer only those questions that were relevant and they were comfortable with, the number of responses in each section/question varied. Due to privacy settings and lack of self-identification in the "other" group it was impossible to identify and analyze responses by NGOs and First Nations.

## 5.2 Water resource status

The literature suggests that the SSRB in Alberta is experiencing pressure with regard to resource availability and quality. The majority of respondents agreed that water is becoming scarcer (68.6%) and that water quality is an issue of growing concern (58.8%).

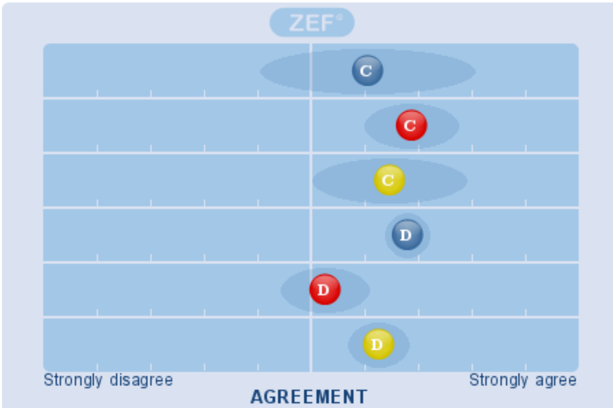


**Figure 5.1 Comparison of perceptions about quantity and quality**

Figure 5.1 represents the comparison of stakeholders' views about water quantity and quality (nodes denoted by "C" stand for quantity, "D" – for quality) across different response groups shown in different colours (blue – others; red – irrigation and municipal and yellow – aggregate). Although aggregate results show that respondents are equally concerned about water scarcity and quality, respondents in the municipal/ agricultural group (red) demonstrate greater concern about resource becoming scarcer than they do with regard to water quality.

Greater concern about scarcity is understandable, considering that the SSRB region has been known for its historical vulnerability to water scarcity. There was more disagreement among users with regard to water quality (C) as compared to water quantity (D). Quality has not yet been an issue to the extent that precludes users from their designated uses. To date, all streams in the basin originate from the Rocky Mountains and, are therefore, relatively pristine as quality is not altered by uses in jurisdictions upstream. In fact, there have been fewer boiling water advisories in Alberta as compared to other provinces in Canada (Vander Ploeg 2010). Respondents in the "other" group reveal greater concerns about water quality than do municipal and agricultural users. In fact, although not yet an issue on a basin-wide scale, diminishing quality is evident in some areas (Matisz *et al.* 2010).

Although respondents do not completely disregard this possibility, there is little correlation between diminishing streamflow and deteriorating surface water quality. According to respondents' comments, higher pollution concentrations have been observed when flow was low. This observation suggests that the relationship between decreasing quality and decreasing streamflow might become more evident if annual average flows continue to decline.

## 5.3 Current system of water allocation and use

The results of the survey largely support findings from the literature with regard to the current system's ability to deliver services pertaining to water quantity and quality. However, results are somehow contradictory with regard to stakeholders' perceptions about the extent of impacts and the perceived importance of preventing pollution by certain sources. Also, there is some mismatch between users' perceptions and the literature regarding pollution by various sources.

### 5.3.1 Perceptions about rights pertaining to water quantity

Secure access to water was found to be relatively important by the majority of respondents (see Figure 4.6). Despite their ability to satisfy immediate needs, municipal uses have been concerned about secure access to water to meet the needs of rapidly growing cities if resource status changes. Similarly, irrigation is a sector known for its dependence on water availability and relatively high withdrawal and consumption rates and is, therefore, vulnerable to uncertainty of supply (Vander Ploeg 2010). However, access by irrigation users is well secured through the position of their licences in the FITFIR system, as licences issued for irrigation purposes are mostly senior compared to licences issued for municipal and other uses. Therefore, upholding the position in the FITFIR system is important for the irrigation sector but not important for the rest of respondents. Participants appeared to agree that the current administration system was rather effective in protecting the system of prior allocation. This observation is consistent with the conclusions by Percy and Weber (2010), and Matisz *et al.* (2010) that it is unlikely that FITFIR will be abandoned. In southern Alberta, the government implemented the market system to allow for reallocation or negotiated compensation while leaving prior allocation intact.

The perceptions about the respondents' ability to secure rights in terms of quantity under the current system are consistent with respondents' opinions about water availability and security of their access to water (see Figure 4.3). Participants' current needs are satisfied mostly owing to relatively abundant supply and lower withdrawals although the watershed has been closed for new allocations, and, therefore, most users are unable to secure more water unless licences are purchased through markets. Users' ratings and comments illustrate the inability of the government to supply more water if the watershed reached the allocation limit. Furthermore, considering unpredictability and a possible decline of future supply respondents suggest that the government will be unable to deliver water in a long run.

Although respondents appeared to understand the inability of the government to issue new licences, they rank relatively low the importance of their ability to transfer licences. A possible reason for this might be relatively abundant supply in recent years and, therefore, dormant markets that can be active if water is in scarce supply. In fact, some market activity was observed only during the prolonged drought in 2001-2002 (Nicol and Klein 2006). Therefore, transferability of the licences can only be appreciated by those who faced a risk of running out of water or experienced markets as buyers or sellers, i.e. the 14.7% of respondents who participated in trading as buyers. The insufficient number of respondents from all sub-basins could have distorted the results with regard to importance of transferability. For instance, according to Bjornlund *et al.* (2007) who performed a survey examining stakeholders' willingness to accept market-based instruments revealed that support for such in the SSRB varied across sub-basins and a higher level of support was found in watersheds with the most reliable and predictable supply. Intensive government regulation and limited transferability might be another potential barrier precluding users from exploring markets. Extensive government oversight is required for all transfers that imply moving water outside irrigation districts, e.g. into municipal uses with higher efficiency yields considering significant differences between the marginal value of water in urban and irrigation uses (Nicol and Klein 2006, Bjornlund *et al.* 2007. Several respondents mentioned the importance of transfers for satisfying future growth. However, respondents' ranking of the system's ability to encourage and facilitate transfers has been very low. According to users' comments, in order to function properly the process of water transfers should be streamlined and users should be given the opportunity to sell saved water.

Given that respondents (n=27) emphasized the importance of renewing licences even for unused water under the current administration, such an issue could be a serious impediment to the adoption of markets. In southern Alberta users face higher risk of losing a part of the unused water in the course of trading as a result of a 10% holdback imposed on transfers via markets (Percy and Weber 2010). According to Percy and Weber (2010) the possibility to lose water through the 10% conservation holdback might prevent senior rights holders from transferring water on a temporary basis in particular, if they know that at the end of the contract period their licence will be reduced by 10%.

In addition to impeding markets, a risk to lose water might discourage conservation. Some of the users' comments suggest that closing watersheds and allowing trading had positive implications and motivated users to engage in conservation activities and increase water productivity by consumptive uses. Irrigation districts and municipalities initiated large-scale infrastructure upgrades, investments in water-efficient equipment, and introduced policies encouraging water-saving behaviours (AECOM 2009, Vander Ploeg 2010).

### 5.3.2 Perceptions about rights pertaining to water quality

Results about the ability of the system to maintain acceptable water quality are consistent with conclusions made in the first section that relatively good water quality is a result of both quality and quantity of the supply and compliance by point source polluters. The performance of the current pollution control system was found to be asymmetrical with regard to identifying and controlling pollution by various sources. Respondents revealed that they perceived agriculture to be a source of pollution in the SSRB, as well as the industrial sector (see Figure 4.5). In southern Alberta, the dominance of the agricultural industry, i.e. density of livestock production and extensive irrigation, indicates the potential for agricultural non-point source pollution as being recognized as a leading source of diminishing surface water quality (Matisz *et al.* 2010). In fact, concentrations of nutrients, bacteria and other pollutants are higher near the areas of intensive agricultural development. It is not surprising that respondents indicated the inability of the system to regulate pollution from non-point agricultural sources.

The existence of significant non-point source pollution in the region has been well documented in the literature and acknowledged by some respondents. However, the overall ranking was rather low with regard to the importance of preventing pollution by agricultural sources, likely it is difficult to identify, attribute and control due to its non-point source origins. Furthermore, matching pollutants to sources might be challenging at locations where both agricultural and urban pollution takes place. Whereas some pollutants, e.g. Protozoan parasites, E.coli and some of the livestock wastes can be identified as dominant forms of agricultural pollution, whereas other pollutants, i.e. nutrients, pesticides and endocrine-disrupting substances, can be a result of both agricultural and urban runoff (Matisz *et al.* 2010, Alberta Environment 2005).

Finally, the majority of respondents agreed that industrial sources were less significant than agricultural but more significant than municipal. Industrial use constitutes a very small portion of total allocations in the SSRB. The potential impact from industrial sources can be more significant in the Red Deer River sub-basin where all allocations for the petroleum industry take place. Industrial sources of pollution are point sources and are therefore, subjected to strict regulations.

The enforcement of pollution control regulations was found to be relatively less important than other rights/responsibilities of the current water administrative system. In general results illustrated the ability of the current system to capture point source pollution only. The literature reveals that effectiveness of existing pollution control regulations diminishes as point sources approach the efficiency limits in their pollution reduction efforts but environmental water quality continues to deteriorate (Woodward and Keiser 2002, Fassbender 1994, Tietenberg 1990). It could be that the pollution enforcement system was not perceived as important as other factors because point sources currently comply with existing regulations.

## 5.4 Proposed system of water allocation and use

Perceptions about users' rights and responsibilities were different under the proposed system both with regard to water quantity and quality. Perceptions about the proposed system revealed relatively higher importance of all rights and responsibilities except the ability to secure/renew the licence even if water is not used, which decreased in importance. The ability to transfer a licence remained the same. Ranking the new system in terms of its ability to deliver rights and responsibilities has not changed significantly but was highest for the ability to hold industrial polluters responsible for water pollution followed by the ability to provide high water quality, enforce regulations to maintain water quality and to hold municipal polluters responsible for water pollution. The proposed system was still perceived weak in its ability to hold agricultural polluters responsible for water pollution, although ability slightly improved when compared to the existing system. Although respondents ranked rather high the importance of securing long-term access to water and satisfy quantity needs, the proposed system was perceived as weak in delivering these rights. The system was perceived as able to maintain users' ability to uphold the position of the licence in a FITFIR system and the importance of this right has increased considerably.

### 5.4.1 Perceptions about rights pertaining to water quantity

Respondents were not provided with extensive details about the proposed system and its possible implications with regard to water quantity. Therefore, results did not show any significance changes with regard to the new system's ability to provide rights and responsibilities pertaining to water quantity. However, water availability is important for planning and maintaining growth and steady growth across sectors is expected in the region (Vander Ploeg 2010). Considering future population growth in the region, the high ranking by respondents is not surprising in conveying the importance of satisfying water quantity needs and to secure long-term access to water. However, the system was perceived as low in its ability to provide both secure access and water quantity to satisfy current needs. Unless access to water is provided by construction of new waterworks, securing long-term access to water will be challenging under any system of allocation. According to Vander Ploeg (2010) most water management opportunities have been explored in Southern Alberta. Factoring into respondents' relatively low ranking might be awareness about the possible decline and unpredictability of future water supplies (Schindler and Donahue 2006). Whereas immediate short-term needs can be partially met through transfers (Horbulyk and Lo 1998), ranking low the ability to transfer licences indicates a presence of impediments in transferring water quantity licences. Limited transferability can also explain low ability to satisfy water quantity needs under the proposed system.

The low ability to transfer licences can be partially explained by a relatively high risk of losing water that is not used. The ability to hold licences even if a portion of a water allocation is not used motivates conservation and can encourage users to transfer licences (Harris Consulting 2003, Percy and Weber 2010). According to the results, respondents ranked low their ability to renew licences even if water in not used, and its importance. At the same time, results demonstrated a significant increase in the importance of upholding water users' positions in the system of prior allocation. Upholding the position in FTFR system becomes critical when resources are scarce and users' rights to use water are protected depending on the position of their licences in this system (Howe 1998). In the absence of the responses from irrigation districts, the largest water users holding the majority of senior licences, it is difficult to determine with certainty the reasons for slightly declined ability of the system to uphold positions of the licences in the FITFIR system.

### 5.4.2 Perceptions about rights pertaining to water quality

Water quality trading programs can take different forms depending on jurisdictions where they are being implemented (Selman *et al.* 2009). Respondents were not provided with a detailed design of the proposed system but the system has several characteristics that are common and well known. For instance, concerns about quality are considered drivers for establishing a pollution cap and pollution trading and, where established, trading has resulted in improved water quality (Selman *et al.* 2009, Woodward and Keiser 2002). Respondents perceived as high the importance and ability of the proposed system to provide high quality water and to enforce such a system. Establishment of pollution markets offer greater flexibility in achieving quality objectives but pollution control enforcement systems are supposed to play an important role in securing compliance (Eheart and Ng 2004). The role of traditional command-and-control measures extends to the establishment of a pollution cap, distribution of responsibilities among polluters, assurance of overall compliance through surface water quality monitoring and adjustment of the pollution cap as water quality improves (Selman *et al.* 2009).

In general, the proposed system was perceived as an improvement in ability to hold all listed polluters responsible for their share of pollution (See Figure 4.7) Benefits from trading between municipal point-source polluters and agricultural non-point source polluters are well documented and trading helped to improve water quality in a cost-effective way where a significant impact from agricultural sources had been established (O'Grady *et al.* 2008, Tietenberg 1990). However, despite increased performance the importance of pollution prevention from agricultural sources is still relatively low, and prevention of industrial pollution is still perceived as important by stakeholders.

## 5.5 Conclusions and future research recommendations

This thesis seeks to explore potentials for improving water resource management system by examining the performance of two distinct systems of administration – government regulation of water quantity and quality and incentive- or market-based instruments – where the water resource is scarce and quality is diminishing. The SSRB in southern Alberta is known for its water scarcity and emerging issues with water quality, and therefore, represents a unique geographic area where conditions for implementing both water quantity and quality markets exist. This research represented the opportunity to examine stakeholders' perceptions about their rights and responsibilities under the current system of allocation with stronger government oversight over quantity and quality and under a new system where users are given more flexibility in managing their resource.

The objectives were to (1) identify stakeholders' perceptions of the current resource status (scarcity/quality), (2) evaluate stakeholders' perceptions of the current water administration including their experience with water markets, and (3) evaluate the willingness to adopt a proposed water quality market mechanism using an online survey instrument.

The results from the survey showed that although current resource status allows secure access to water of desirable quality in the short run, the situation is likely to change resulting in increasing water scarcity and diminishing water quality. The ability of the existing system to satisfy current needs is associated with current resource status and relatively low withdrawals by consumptive users. Therefore, satisfying water quantity needs, including environmental, under the current system might be challenging in the face of growing demand. Although water quality does not pose a problem in the short run and control over point source pollution is relatively strong, respondents highlighted the need to find a viable solution to improve identification and control by non-point sources.

Perceptions about the current system's ability to deliver and the importance of a suite of rights and responsibilities revealed that the six most important characteristics were the ability to hold industrial polluters accountable, to provide high water quality, to secure/renew licences even when not used, to satisfy water quantity needs, to secure long-term access to water and to hold municipal polluters responsible. While these aspects of the system were judged to be relatively important, the current system's ability to accomplish such was rated relatively weak for licence security and satisfaction of water quantity needs. Relatively less important was the ability to hold agricultural polluters responsible for water pollution, enforcement of regulations to maintain water quality, the ability to uphold the position of a licence, and the ability to transfer a licence.

Perceptions about the proposed system revealed relatively higher importance of all rights and responsibilities except the ability to secure/renew the licence even if water is not used which decreased in importance. The ability to transfer a licence remained the same. Furthermore, it is important to assess the new system in terms of its ability to deliver rights and responsibilities. Ranking highest was the ability to hold industrial polluters responsible for water pollution followed by the ability to provide high water quality, enforce regulations to maintain water quality, to hold municipal polluters responsible for water pollution and to uphold the position of the licence in FITFIR system. Where the new system was perceived as weak was the ability to satisfy water quantity needs and secure long-term access to water, to hold agricultural polluters responsible for water pollution, and the ability to transfer a licence, the latter of which is surprising given that markets are authorized and demand is increasing.

Finally, survey results revealed that the majority of respondents voted in favour of adopting the proposed system, although the referendum failed to reach the specified minimum of 51%. According to Howe *et al.* (1986) an optimal system of resource allocation would be one perceived by users as efficient, equitable and one that creates incentives for conservation. Although some findings were indicative of increased efficiency, e.g. improved performance in holding some polluters responsible, other findings indicated less efficiency, e.g. limited rights transferability. Equity is implied when transfers are voluntary (Howe *et al.* 1986) and costs of compliance with an established pollution cap are equalized among sources (Tietenberg 1990, Eheart and Ng 2004). Transferability is an important condition for efficiency as water is securely held by the same users unless it can freely move among users with different marginal values. Considering increasing scarcity and the inability to secure new licences, the relative low ranking of transferability on the importance axis is surprising, unless it indicates the presence of significant institutional constraints that influence stakeholders' attitudes towards markets in general. Therefore, limited transferability of water licences along with the possibility to lose water constitutes barriers to efficiency and equity, and adoption of the proposed system by greater than 51% of respondents. Also, insufficient participation from irrigation districts and the lack of respondents from the southern sub-basins have possibly distorted the results with regard to examining users' perceptions about transferability, and the extent of pollution impacts by various sources.

Recognition of benefits and lack of essential information have factored into the result of the hypothetical referendum: the proposed system did not pass although the greater number (40.9%) voted in favour of the system. The ultimate decision on adoption of the proposed system would be subject to a greater certainty of outcomes in view of resource status, future regulations of water quantity and a clear understanding of origin and impact by pollution sources.

### 5.5.1 Future research recommendations

Possible areas for future research extending from the findings of this thesis would be, first of all, modifying the survey to address in more detail the interrelatedness between water quantity and quality in the context of the SSRB in Alberta. For instance, users' willingness to leave water instream for compensation or to pay for improving the assimilating capacity of the stream were not measured but would be important determinants in accepting a new administrative system. Although the proposed system does not directly address water quantity issues, considering the interrelatedness of water quantity and quality and how it could influence water-use decisions, it would be important to determine the extent to which this interrelatedness is captured by regulations. For instance, if private licences to instream flow are authorized, then users could purchase or leave water instream to improve a stream's assimilating capacity and offset pollution (Andersen and Snyder 1997). In contrast, if there is a risk of losing unused water, users' decisions will be guided by a need to use water rather than leaving it instream or transfer to other uses (Bjornlund 2010, Kwasniak 2006). Responses revealed the importance of the ability to secure/renew a licence even if water is not used, a right that if not provided could diminish security of tenure and prove inimical to conservation. Considering that existing legislation does not specifically authorize private licence holders to establish the ownership to instream flow, any water left or transferred instream might be regarded as unused and lost (Kwasniak 2006). Therefore, the proposed system will lack incentives to leave water instream as this water will be regarded by regulators as unused and might be reallocated into other users. Asking respondents, senior licence holders in particular, about perceived changes in their rights if private licences to instream flow were legitimized would help to assess private incentives to enhance instream flow and inform future policy directions.

Willingness of private users to transfer water instream for improving the assimilative capacity of the stream will also depend on future resource status and availability of higher demand for better water quality. When rights are privately held and transferable, users have incentives to move resources into higher value uses (Stroup and Baden 1979). For example, if demand for better water quality is high, then users will have incentives to leave more water instream whenever needed to improve water quality. While the results showed the importance of water quality, there was no measure of such quality. It would be important to further investigate users' preferences with regard to water quantity and quality in view of current and future resource status to determine users' willingness to pay for better water quality in terms of specific measures, or accept compensation for leaving water instream. If demand for better water quality exists and the perceived strength of users' rights improve, stakeholders might be more willing to accept the proposed system.

It would be also useful to examine whether a reduced risk of losing the unused water and the ability to hold private licences to instream flow would improve the perceptions of licence transferability and, as a result, users' perceptions about markets in general. The obtained results could be used for comparing users' perceptions about their rights under the current system, when the possibility to lose unused water is high. It will be also useful to further observe changes in users' perceptions about the performance of a system to uphold the position of their licences in the FITFIR system if saved water could be sold and the risk of losing water were reduced.

In order to assess the likelihood of adopting a proposed market system it will be necessary to develop better insight about the origin and impact of pollution by various sources. Prior to establishment of point to non-point source trading programs it would be important to ensure that credits generated by nonpoint sources would contribute to overall pollution reduction that would not occur otherwise (Selman *et al.* 2009). It is particularly important in the SSRB where according to respondents' opinions agricultural sources are recognized as contributors to pollution but holding agricultural polluters responsible is perceived as not important and the ability of both systems weak.

Finally, in order to assess the acceptability of a proposed system it will be important to further examine perceptions from the irrigation sector, which were underrepresented in this survey. According to Bjornlund *et al.* (2007) and Bjornlund (2010) there is little support for market-based instruments by irrigation districts primarily due to lengthy process of approval.

Considering that the irrigation sector is the largest user of water in the SSRB, and holds the majority of senior licences, perceptions by this sector about incentives created by the proposed system might inform future policy with regard to water use and pollution regulations.

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## Appendix A - Survey questions

Invitation

This survey is being conducted as part of my research to complete a Master degree at the School of Environment and Sustainability, University of Saskatchewan. I am examining stakeholder perceptions of alternative approaches to managing water quantity and water quality.

Considering a steady trend in urban growth and intensive economic development, water users will have to find optimal solutions to improve water management and pursue approaches that would address the issues of quantity and quality conjunctively. However, before examining suitable policies it is important to consider stakeholders values and perceptions, and advantages and disadvantages of administrative changes.

The purpose of my survey is to:
(i) Determine your perceptions of current water resource conditions in your area,
(ii) Understand your perceptions of the current water administration, including your experience with water markets in your area; and
(iii) Garner your opinion on adopting water quality markets (e.g. nutrient trading).

This survey will take approximately 10-15 minutes. Introduction

*Please note*: your participation is voluntary and you may quit the survey at any time. All data are confidential and your participation is anonymous. This survey has been approved by the University of Saskatchewan Research Ethics Board.

Please consider two scenarios: the status quo as the current water administration, and a proposed change to the water administration.

Status Quo/Current Administration: In the southern part of Alberta users who require more water may purchase water on the market. Instream flow needs are specified and maintained by government regulation establishing minimum flow requirements for each sub-basin.

The government also regulates water quality and is responsible for issuing discharge permits to municipal and industrial sources and monitoring compliance and environmental water quality.

Proposed Water Administration: the Government of Alberta could introduce a pollution cap that specifies the maximum amount of pollution allowed into a water source.

The sum of all permits would account for the total allowable quantity of a specified pollutant in a water source (as specified by the “cap”).

Those who wish to discharge more pollutants (for example those arising from nutrients such as phosphorus and nitrogen) would be required to purchase additional permits.

Where implemented, quality trading markets created incentives for previously unregulated pollution sources to reduce pollution. A pollution cap will result in higher compliance costs in the short run for some polluters who can be identified. Under the proposed system, polluters with high compliance costs lower their costs by purchasing permits from sources with lower compliance sources. Thus, the proposed system promotes equity in pollution abatement. In general, water quality markets create incentives to reduce pollution and improve environmental water QUALITY.

Questions
(Multi choice)
Are you willing to participate in survey? (Yes/no)

Resource status
Identify whether you agree or disagree with the following statements:

Water is becoming more scarce (Multi Choice Question)
Agree
Disagree
Not sure

Water quality has decreased (Multi Choice Question)
Agree
Disagree
Not sure

Water licences
Do you have a right to transfer your licence?
Yes
No
Don't know
I don't have a licence

I have participated in a water transfer as
A buyer
A seller
A regulator
None of the above

Water characteristics – scarcity

We would like your opinions on water SCARCITY in your area. Please consider the following statements and indicate your agreement (scale)

(1) I have secure access to water
(2) I have sufficient water for my needs
(3) I have ability to secure a water licence
(4) Please provide free comments on water scarcity in your area

Water characteristics – quality

We would like your thoughts on water QUALITY in your area. Please consider the following statements and indicate your agreement (scale)

(1) Municipal wastewater is polluting surface water
(2) Industrial wastewater is polluting surface water
(3) Agricultural wastewater is polluting surface water
(4) There is not enough water instream to assimilate waste in surface water
(5) Please provide free comments on water quality in your area

Current water administration

We would like your thoughts on your current water administration to assess the types of rights and responsibilities you think are IMPORTANT to water management, and the ABILITY of the current administration to provide such rights and responsibilities.

*Note*: we are asking two questions simultaneously. Importance is measured on the vertical access and the ability to provide rights is measured on the horizontal access. If you find a type of right/responsibility important, but that the current administration does not have the ability to provide the right/responsibility, you would mark your answer in the upper left quadrant for example.

(1) The ability to satisfy water quantity needs
(2) The ability to provide high water quality
(3) The ability to transfer licences
(4) The ability to secure/renew licences even if water is not used
(5) The ability to uphold the position in FTFR system
(6) Enforcement of regulations to maintain water quality
(7) The ability to secure long-term access to water
(8) The ability to hold municipal polluters responsible for water pollution
(9) The ability to hold agricultural polluters responsible for water pollution
(10) The ability to hold industrial polluters responsible for water pollution
(11) Please provide any comments you wish to make regarding the current water administration

Proposed water administration

We would like your thoughts on the PROPOSED water administration to assess the types of rights/responsibilities you think are IMPORTANT to water management, and the ABILITY of the proposed administration to provide such rights/responsibilities:

(1) The ability to satisfy water quantity needs
(2) The ability to provide high water quality
(3) The ability to transfer licences
(4) The ability to secure/renew licences even if water is not used
(5) The ability to uphold the position in FTFR system
(6) Enforcement of regulations to maintain water quality
(7) The ability to secure long-term access to water

(8) The ability to hold municipal polluters responsible for water pollution
(9) The ability to hold agricultural polluters responsible for water pollution
(10) The ability to hold industrial polluters responsible for water pollution
(11) Please provide any comments you wish to make regarding the current water administration

Voting for the proposal

Imagine that the PROPOSAL described above will be put to a referendum where if 51% of voters are in favour, it will pass:

Would you vote in favour of accepting the system proposed?

Yes
No (why not?)
Don't know

Demographics

Select the category that best describes you;

Agricultural (please, specify)
Municipal
Other (please, specify)

Nearest town/city

Age

18-25
26-40
41-60
61+
Prefer not to say

Location

Rural
Urban

Gender

Male
Female
Prefer not to answer

Education

K-12
Bachelor's degree
Master's degree
PhD
Trade school
Prefer not to say

Income

Below $29,000
$30,000 – $59,999
$60,000 - $79,999

$80,000 - $99,999
$100,000 - $149,999
Above $150,000
Prefer not to say

## Appendix B – Anonymous comments

**Water scarcity and quality**

**Scarcity**

Municipalities

- No surface water;
- Arid community;
- Water conservation measure in place (water by-law, low flush toilets, etc.);
- Community has a sound understanding of water conservation, but is growing;
- Community must live within carrying capacity of local watershed - must find potential water license transfers for short and long term;
- New developments on outskirts of community will increase local water demands; thus providing even less water per day, per capita;
- We have plenty of room in our current license for any growth we may have. I feel in Alberta as a whole, water is becoming scarce, but we are ok;
- River basin is over allocated, no new licenses are being issued.
- We access water through a regional water line. Although the supply to us is secure, we don't know about where the supply originates;
- Semi-arid area, although the last 4 years we have had more than average rainfall. During 2000 - 2002 the area experienced drought conditions which seen potable water usage at all time highs although we were able to supply and stay within our annual diversion amounts from the Red Deer River;
- We have a licensed water withdraw volume that well exceeds the present requirements of the Town.

Irrigation

- No

Others

- Concerned about future water needs and with more urbanization, there is adequate water for citizens, and affordable;
- Water scarcity is less a concern than water quality;
- Closed basin for surface water allocations. Instream flow needs are not even close to being met in many areas of the SSRB. Water conservation objectives are considerably below IFNs in some areas. Government should entertain and issue as appropriate private instream flow licences, as these are permitted by the legislation;
- The South Saskatchewan River Basin, the source of our supply is closed to new water licences. We can only grow by becoming more efficient in the short term;
- I am in central Alberta so the conditions on water quantity differ. I don't not have a commercial interest in water, I care primarily for the health of aquatic ecosystems;
- I do not have a water licence, nor do I need one. In Edmonton our water for home use comes from the North Saskatchewan, however quality and quantity is in decline. Water quality and quantity is a big concern with Alberta First Nations - they often do not have the ability or leverage to purchase a water licence;
- There is no shortage in my area generally, with the exception of the specific industrial area known as the, Edmonton Heartland;
- Sufficient water is generally available to all existing water users. New water users in the Bow and Oldman Basins need to secure a water license from an existing license holder, since these basins are closed to new license allocations;
- During drought years water can be scarce, particularly for high water users such as irrigation and golf courses. Some rationing is also required in some towns;
- There is sufficient water in this area to meet all needs. Water may need to be transferred from other license holders for new water users.

## Quality

Municipalities

- Small community, limited water pollution from industry. Agricultural un-off from surrounding farmers into watershed or rivers may be troublesome if proper riparian zones are not established;
- Experiencing this now with excess nutrients entering reservoir due to outdated farming practices;
- We discharge from our lagoon once a year in the fall... the creek we discharge into is low at that time. The water that is discharged is fairly clean, well within "limits" set by Environment;
- For profits (industrial) need to save as much money as possible to increase profits for shareholders. Unless they are monitored much closer there is the possibility of polluting the ground water. Likewise for agricultural runoff;
- The quality of potable water in my area is affected by both natural and manmade activities. Spring runoff / snow melt result in very high sediment values. Low flow rates results in microbial growth. Human activities add undesirable elements. These and other factors result in stringent processing efforts to meet potable water standards.

Irrigation

- Nutrient levels are higher than ideal, but probably better than they were prior to municipal WWTP upgrades. Very little non-point source pollution except during runoff following heavy precipitation, which is not common most years. Other pollutants do not appear to be a concern at this time.

Others

- Concerned about oil industry pipeline breaks near waters, e.g. rivers, streams.
- Water quality varies depending on seasonal flows;

- By "my area" I include the SSRB;
- I am more concerned about endocrine disrupter in water than nutrients or turbidity or heavy metals or salts. Our heavy metal loads are mostly natural, and N and P not horribly high, but we don't know impact of people drinking water with hormones etc from municipal discharge. The levels of pathogens are not well known, though the level of fecal indicators is. River flows are high enough to make it difficult to measure small amount of contaminants in runoff, but cumulatively these are probably high. City of Calgary and City of Lethbridge are significant sources on pollutants -- perhaps more than all others combined;
- We are continually improving our infrastructure to reduce our impact from both point and non point source discharges;
- I am concerned with lakes, not rivers;
- It is not (only) water in stream that is necessary to assimilate waste water but the riparian areas, wetlands, and aquatic vegetation that is crucial to fill this role. These have been compromised in many areas;
- The water quality is reasonable. It declines downstream of Edmonton, but is sufficiently good as not preclude other uses.

**Current system**

Municipal

- Very time consuming.
- Difficult to get new water license, or water license transfers. Must think of alternatives for water supply and management with a growing urban population and limited water resources;
- In Alberta, municipalities do not have authority / jurisdiction over water. Alberta Environment is the agency with such authority.

Irrigation

- It is a good system. There should be some streamlining of the licence transfer process. Point source pollution is dealt with quite well, and under any system non-point source are hard to handle.

Others

- Don't license all the water away; save licensing for future needs;
- Do not allow for selling licensed water and allocations not used could be returned to the overall needs;
- Ensure adequate water for urbanization as more people will move to cities;
- For municipalities and other point sources, water administration has tools for management; for non-point source s, no tools for management and enforcement. Water quantity tools strong if not used frequently except for environmental needs;
- Should better regulate non-point source including agricultural sources;
- Are you talking the current government and its policies and legislation? It was hard to answer previous questions not know your definition of water administration;
- The current GoA Administration has a major role as per Water for Life goals. We need safe, secure drinking water, water for healthy ecology and sustainable economy. Since water supplies are indeterminate, the administrator has to manage those supplies within the restrictions of supply and ecological needs -- i.e., some of the water is available for industry, agriculture, and municipalities. It is everyone's responsibility to protect the quality of the water within economic reason and make the best use of water diverted from natural systems, and find better ways of managing use. Transfers are a method to move water volumes to users who need them, and this process is in its infancy and needs time to see how well it works. Non-point source pollution is challenging to control, but steps are being taken to do that. Point source pollution is better managed, but people have to live somewhere and so cities wind up being major pollution sources;
- In my opinion, the water administration is quite competent. Like every other water regulator, it is difficult to deal with non-point source pollution, especially in agricultural run-off;

- Current water administration works quite well. However, the system can seem bureaucratic, and slow because of requirements to ensure that any water transfer will not harm existing water users. This requires a great deal of analysis and computer modeling;
- Considerable research is being carried out in Alberta to assess future water supply and needs within changing climate scenarios.

**Proposed system**

Municipalities

- Water quality is not so much an issue. Water license transfers are needed for short and long term water supply; especially with a growing population and encroachment on local watershed from new developments;
- In Alberta, municipalities do not have jurisdiction or authority over water.

Irrigation:

- It does not address quantity, so I hit "no answer" on all quantity questions. I did the same for quality because the importance of quality issues is identical, no matter which system is used, and I did not want my ranking of importance to differ from my ranking under the status quo. One problem that I see with the proposed system is the difficulty in addressing non-point source s, and the possibility of point source polluters having to indirectly allow for highly variable non-point source pollution within their limits.

Others:

- Should be reviewed every three years and an active file as our province grows and changes;
- FYI this survey wasn't user friendly with the quadrant questions;
- What is proposed water administration? This is not defined so I cannot answer your questions;
- The questions are a little difficult. Administration alone cannot make more water

available in those regions where the law says that no new licences can be issued. Similarly, administration cannot allow licences to be transferred in those regions the province where transfers are not permitted by law. Administration cannot safeguard rights which are not used under license, as the law says the license expires if there is no use over a period of three years. Some respondents may be critical of administration in these areas, but it's really a question of the present state of the law

- The Cumulative Effects Management System (CEMS) being proposed by Alberta Environment and Sustainable Resource Development is designed to target polluters more effectively, through monitoring, analysis and active participation with stakeholders. However, I'm not aware that serious discussion has yet taken place about purchasing additional "pollution" credits, or "trading" pollution credits. I do not agree with these concepts. In my mind, CEMS is about isolating and mitigating a problem, not collecting money to allow a problem to continue.